AGGREGATE OPERATORS BEST MANAGEMENT PRACTICES HANDBOOK

for

BRITISH COLUMBIA

VOLUME I

Introduction
and
Planning

(**Volume II** - Best Management Practices
as separate printable document)

BRITISH
COLUMBIA

MINISTRY OF
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Foreword

The foundations of our communities are literally built out of aggregate. In British Columbia, about 11 tonnes of sand, gravel and crushed rock per person per year are used to maintain infrastructure such as roads, sewers and utilities. An additional 2 to 4 tonnes are used for the construction of new homes, public and commercial buildings and schools. All told, the annual per capita consumption of aggregate in BC is about 14 tonnes -- the equivalent of one fully loaded dump truck.

British Columbia has abundant sand, gravel and quarry rock resources. Many of our communities have local aggregate resources that can supply their own consumption needs well into the foreseeable future. These deposits are formed and transported by natural geological process and cannot be relocated. The extraction of aggregate from deposits located within and adjacent to local communities often leads to social and environmental conflicts.

The aggregate industry largely develops local resources for local markets. Aggregate is needed as the raw material for building and maintaining a community's infrastructure and buildings, and it is least expensive when extracted, processed and distributed locally. Aggregate operations can be significant contributors to the provincial and local economies. The 1998 provincial production value for construction aggregate was more than $400 million dollars, greater than that of gold production for the same period.

This handbook provides technical information, guidance and best management practice options to sand and gravel pit and rock quarry operators for many aspects of planning, operating and reclaiming aggregate operations in British Columbia. Best Management Practices (BMPs) are tried and true solutions to common pit and quarry issues, challenges and problems.

Using the BMPs and the other planning tools described in this handbook may help producers supply the aggregate needs of local communities while supporting local economies, respecting neighbourhood values, and operating with environmental responsibility.

Incorporating BMPs into an aggregate operation may:

- provide for effective, economical and safe stormwater management and discharge,
- provide for effective and safe erosion and sediment control,
- reduce siltation of aquatic habitats and storm water conveyance systems,
- control dust through minimizing exposed soil areas, re-establishing vegetation and promoting the use of buffers,
- aid in the planning, design and implementation of settling ponds for process water and the proper disposal of the resultant mud,
- control noise emissions through strategic placement of points sources and buffering structures, and reductions in transient noise generating activities,
- discourage garbage dumping at aggregate operation sites,
- provide pollution control through equipment management and maintenance, proper fuel handling, spill avoidance and emergency planning,
- aid in planning for and implementation of reclamation for subsequent land uses,

- promote an ethic of environmental responsibility and land use stewardship,
- reduce traffic conflicts through planning and driving protocols, and
- aid in reducing visual interruptions thought site layout and design.

This handbook was written and compiled by the British Columbia Ministry of Energy and Mines (MEM), with the assistance of a dedicated committee of stakeholders. The authors have drawn heavily on previous work by aggregate producers and professionals from around the world.

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Disclaimer

ANY PERSON CHOOSING TO EMPLOY ANY OF THE PRACTICES SET OUT IN THIS HANDBOOK DOES SO AT THEIR OWN RISK, AND THAT PERSON ASSUMES FULL RESPONSIBILITY FOR ANY AND ALL CONSEQUENCES ARISING FROM THE USE OF THOSE PRACTICES.

The Aggregate Operator's Best Management Practices Handbook for British Columbia (Handbook) is intended as a general guide to assist aggregate operators. As a general guide, the practices set out in this Handbook may not be appropriate for all circumstances. Accordingly, users of this Handbook must use their own judgement as to whether the practices set out in this Handbook are appropriate for any particular situation.

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Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement.

PART I

Chapter 1

Introduction

This handbook was prepared to assist aggregate operators in understanding common concerns associated with aggregate operations and to help them in planning and selecting Best Management Practices to effectively manage those concerns. The principle advice of this handbook is to ***plan ahead, plan carefully, operate responsibly and reclaim with an eye to subsequent land uses***. Anticipating challenges is considerably more cost effective than trying to compensate after the fact.

This BMP handbook is designed to be a practical, user-friendly reference and learning tool for all aggregate producers in British Columbia. It includes both thorough discussions of BMP options and quick references in the form of tables and illustrations. It can be used to assist in both mine planning and day-to-day operations. Readers are referred to the glossary (Appendix 1) for explanations of terms, and the acronym chart (Appendix 4) for the long hand versions of organization names or phrases.

The detailed planning, operating and reclaiming of an aggregate operation, especially in the case of larger mines, can be a complex multidisciplinary task that goes far beyond the scope of this handbook. Trained professionals such as agrologists, biologists, geoscientists, engineers, environmental scientists, hydrogeologists, landscape architects, planners and soil scientists may be helpful in designing and managing a project. Aggregate producer associations, trade and other government publications, government agencies and equipment suppliers may also have to be consulted. For more detailed advice on pit and quarry reclamation, it is recommended that operators refer to the Reclamation and Environmental Protection Handbook for Sand, Gravel and Quarry Operations in British Columbia, available from the Ministry of Transportation.

How to Use This Handbook- A Step-by-Step Approach

This handbook is divided into two parts. Part One discusses in general terms the broader aspects of planning and operating aggregate sites. It includes discussions of environmental protection issues and the interests of various stakeholders.

Part Two focuses on the "how to" of planning and operating to avoid safety, land use and environmental problems. After introducing the basics of preparing a mine plan and related maps, it presents nine modules covering such topics as noise, stockpiling and traffic. Each module is a self-contained guide for a particular topic. Ideally, all of the modules should be useful in planning an operation. Through work tables, the modules suggest ranges of BMP options adaptable to individual sites.

What are Best Management Practices

BMPs are managerial, operational, and structural measures that can be used to prevent, reduce or mitigate various undesired impacts that an operation may cause. Examples may include:

- a treed berm that is used as a visual screen and to intercept dust and noise,
- scheduling of clearing to avoid nesting seasons, and
- the practice of reducing the height from which aggregate is dropped into trucks to reduce both dust and noise.

Each of the Infosheets in Chapter 7 of this handbook describes one BMP. BMPs can be used individually or in combination, and in a wide variety of applications. To be effective, BMPs must be used appropriately and with competence.

As the BMP Infosheets are simply tools for doing things more effectively, they do not always apply and do not replace legislation or regulations. Unlike the Chapter 5 modules, they are intended to be used selectively. Each situation should be individually assessed and BMPs chosen to suit the uniqueness of the operation.

All of British Columbia's Provincial statutes and associated regulations can be found on the Internet at http://www.qp.gov.bc.ca/statreg/ Regulations detail how statutes are enforced by the Provincial ministries responsible for each particular statute.

To assist with selecting BMPs, this handbook includes numerous tables that present a range of BMP options. In Chapter 7, all BMPs have in their top right hand corner a "USER" list of potential applications.

Chapter 2

Common Community and Environmental Concerns

This chapter briefly reviews common community and environmental concerns with respect to aggregate production, as background for later chapters that discuss ways of addressing those concerns.

Community Context

Common community concerns regarding aggregate operations include:

- Noise
- Dust
- Traffic
- Appearance (Viewscape)
- Hours of operation
- Water management

These concerns can be managed with adequate mine planning, diligent procedures, appropriate use of BMPs and, on a larger scale, by integrating aggregate operations with local community planning.

New aggregate operations often locate near existing urban and rural developments. The type and proximity of adjacent land uses may influence many of the mine planning and operating decisions. For example, in a community where tourism is important, an operator may choose to begin extraction at a less visible part of the property and establish a perimeter berm with fast-growing trees that will eventually become an effective visual screen. Table CEC - 2 lists common community concerns related to aggregate operations, and highlights the modules and some sample BMPs in this handbook that can be used to lessen the effects of those concerns.

Image CEC - 1: Fast growing poplar hybrids on a gravel pit's landscape berm in Sechelt, British Columbia. Growing up to 3 metres a year, these hybrids can provide a quick effective visual screen and block noise and dust from leaving the site. They can also be harvested in 12-14 years for pulp, leaving a healthy stand of evergreens that will eventually cover the berm. Photo courtesy of: Construction Aggregates Limited, Sechelt

Operation and SYLVIS Environmental of Vancouver.

Table CEC - 2: Common community concerns

CONCERN	MANAGEMENT CHALLENGE	MODULE	SAMPLE BMPs
Noise	• Noise from equipment operations, loading and transportation can affect a wide area around a pit or quarry.	Site Layout • Noise Section	• Berm • Buffer Zone
Dust	• Dust from exposed soils, traffic and processing may create a nuisance for local agricultural operations, nearby residents and businesses.	Site Layout • Dust Section	• Drop Height • Water Spray
Traffic	• Large dump trucks used to carry aggregate may increase traffic, affect road safety, create dust and increase road maintenance requirements.	Traffic	• Tarps • Wheel Washer
Viewscapes	• By their nature, aggregate operations disturb the land, and the appearance of the site from adjacent areas may be unattractive.	Site Layout • Visual Landscape Section	• Berm • Lighting Management • Vegetation Cover
Hours of operation	• Operations in the early morning, evening and weekends are more noticable and are therefore more likely to cause concern than operations during regular business hours.	Extraction	
Water Management	• Extraction of aggregates requires the removal of vegetation and the exposure of soils and can alter stormwater drainage patterns. This exposed soil may pick up sediment if not managed appropriately.	Stormwater & Erosion Control	• Ditches • Check Dams • Retention Basin • Silt Fence

Integration of aggregate operations into communities can be challenging, but workable solutions can often be found through cooperation and coordination of mine planning with local planning processes. To assist in this effort, refer to Chapter 4 of this handbook.

Environmental Concerns

In an undisturbed state, sand and gravel and quarry rock are environmentally benign materials. Environmental concerns arise because aggregate resources cannot be extracted from the landscape without causing some disturbance. Care must be taken to ensure that the effects on the environment (i.e. plants, animals, soil, water and air) and the landscape are appropriately considered when formulating plans for extraction, operations and reclamation.

Pairing of environmental concerns to appropriate modules and BMPs can begin with Tables CEC - 2, 3 and 4 in this chapter or the "Identifying Potential Environmental Issues" section of the Risk

Management Module (RMM). The RMM can help the operator identify potential environmental concerns through references to numerous sources of information.

All aggregate production must be carried out in an environmentally sensitive manner. This can be accomplished through careful planning and BMP use on the property, and through coordinating on-property activities with the environmental activities of the immediate neighbouring area. For planning purposes, information concerning local environmental activities can be found in the environmental goals, strategies and plans of the Official Community Plan or Growth Strategy (as defined in the *Local Government Act)*, or where there are federal or provincial environmental guidelines.

Table CEC - 3: Common environmental concerns

Concern	Impacts	Module(s)	Sample BMPs
Stormwater	• increased erosion and siltation	Stormwater & Erosion Control	• Ditches • Retention Basin
Groundwater	• reduced filtering capacity • altered recharge rates • lowering of groundwater table • contamination	Risk Management	• Ditches • Pollution Prevention
Water Quality	• increased total suspended solids (TSS) • increased turbidity • increased hydrocarbons	Stormwater & Erosion Control Risk Management	• Oil/Water Separator • Settling Pond • Silt Fence
Water Discharge	• increased siltation	Stormwater & Erosion Control Processing	• French Drain • Retention Basin
Acid Rock Drainage	• increased acidity	Refer to the MEM Acid Rock Drainage Guidelines, available on-line at <http://www.em.gov.bc.ca/mining/MinePer/ardguide.htm>, or contact a local MEM office.	
Loss of Plant Cover	• degraded topsoil • erosion • changes to runoff and percolation rates.	Stormwater & Erosion Control Stockpiling	• Erosion Control Blanket • Topsoil Management
Wildlife Habitat	• loss of habitat	Stockpiling	• Buffer Zone
Fish Habitat	• increased siltation and degradation of fish habitat	Stormwater & Erosion Control Processing Site Layout	• Buffer Zone • Settling Pond • Silt Fences

Water Management

Water management is often the most significant environmental concern at an aggregate site. This concern includes stormwater management, groundwater and surface water protection, and discharge options for stormwater and process water. An illustration of a water budget, showing how water can pass through an aggregate operation, is depicted in figure CEC - 5.

Stormwater

"Stormwater" is the portion of rainfall or snowmelt that does not immediately percolate into the ground or evaporate. Stormwater flowing across exposed soils can pick up fine clays and silt which, if not managed properly, *will* negatively impact offsite water quality. For further discussion of stormwater management on aggregate sites and its potential environmental concerns, please refer to the Stormwater and Erosion Control Module.

Surface Water

"Surface water" is water that flows in streams and rivers, or is stored in natural lakes, ponds, wetlands and human made reservoirs. This water can be used for any number of applications from agriculture to drinking water. Extreme care should be exercised whenever aggregate operations interact with surface waters. For discussions on pollution prevention, refer to the Risk Management Module, "Emergency and Spill Response" section, and related BMPs.

Operations that use, or are located in the vicinity of surface waters must comply with the *Water Act*. For water use, either a licence (for long-term use) or a section 8 approval (for short-term use) is required. For any construction or resource development in or about a stream, a section 9 approval is required in the case of major works (diversions, rip rapping), and a notification form outlining the proposed work must be submitted in the case of minor works. The federal *Fisheries Act* may also apply if an operation is likely to affect a fishery.

Table CEC - 4: Aggregate activities and their potential environmental concerns.

Mining Activity	Activity Details	Potential Effects on Environment	Sample BMPs
Clearing, Grubbing and Stripping	• timber clearing • vegetation removal • soil removal • overburden removal	• removal of hydrological buffers / filters • habitat loss or disturbance • soil exposure	• Tillage • Topsoil Management • Vegetation Cover
Extraction, Processing & Transport	• blasting • crushing • stockpiling • waste rock management	• dust generation • noise generation • water quality impacts	• Berm • Pollution Prevention • Settling Pond • Water Spray
General Operations	• stormwater management • erosion and sediment control	• increased runoff • increased erosion • increased sediment load • increased groundwater recharge	• Buffer Zone • Retention Basin • Silt Fence
Reclamation	• staged • interim • final	• re-establishment of habitat	• Bioengineering • Grading • Vegetation Cover

Groundwater

Sand and gravel pits do not always contaminate groundwater either directly or indirectly, but may increase the risk of groundwater contamination by removing vegetation and soil buffers. Assessments should always be made on a case-by-case basis. The potential impact of an aggregate operation on a groundwater system depends upon a number of factors, including:

- presence of a groundwater source below an operation,
- characteristics of the groundwater system,
- characteristics of the gravel deposit and operation,
- thickness of the overburden,
- presence of clay or bedrock immediately under the sand and gravel deposit, and
- climate.

Potential Effects of Aggregate Production on Groundwater:

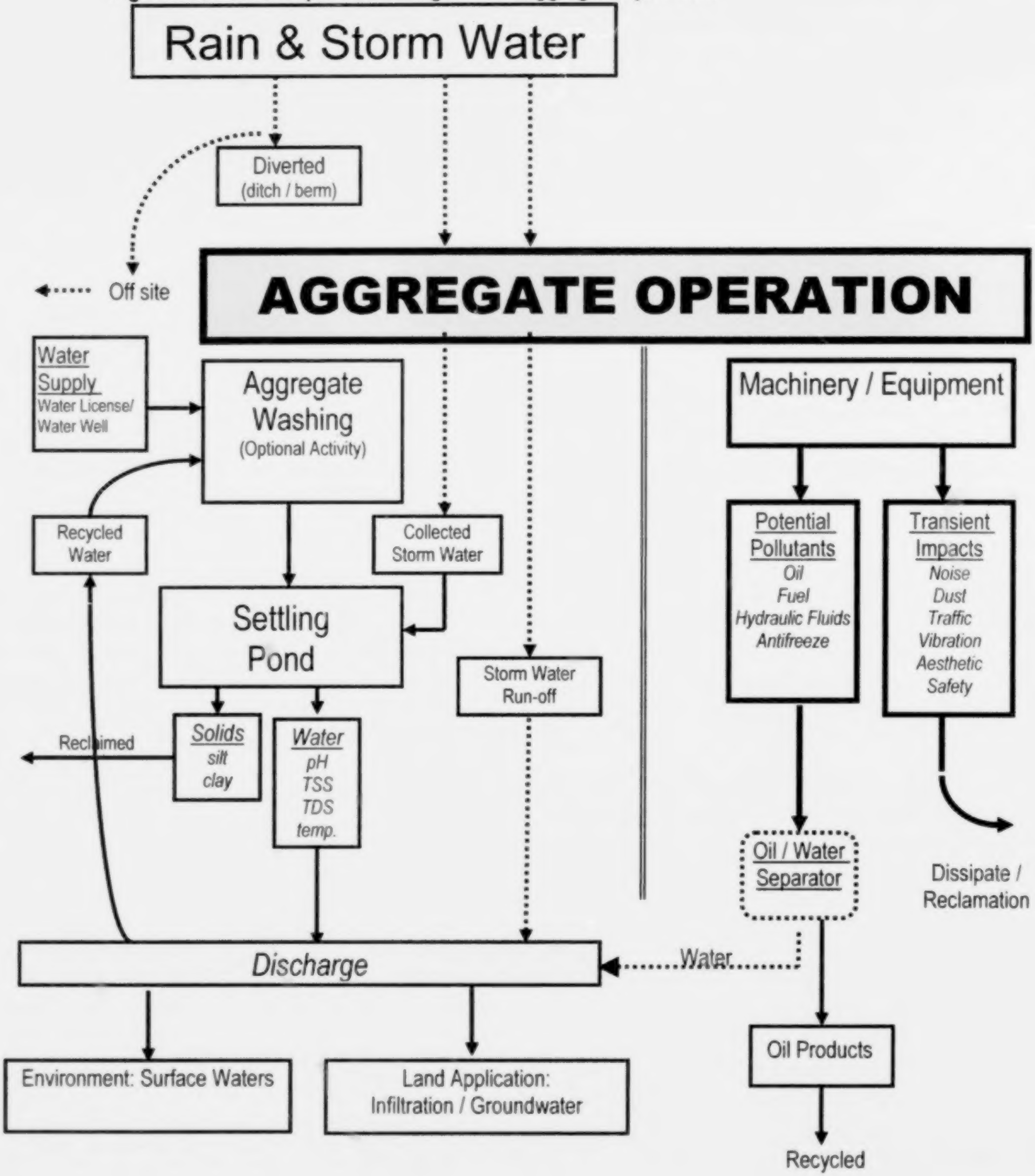
1. **Decreased Safety Margin for Pollution Prevention** - By reducing the thickness of unsaturated sediments above the groundwater table, an aggregate operation may affect the ability of those sediments to ameliorate contaminants. The use of operational practices such as regular maintenance, proper fuel handling, spill avoidance, use of spill kits and emergency planning will keep contamination as low as possible. These measures can be planned using the "Stormwater, Emergency and Spill Response" section of the Risk Management Module and the Traffic Module from this handbook. These provisions should be described in the Notice of Work and Reclamation application for sand and gravel pit and rock quarry permits.

2. **Altered Groundwater Recharge Rates** - Vegetation, together with soil, may act as both a filter and a sponge and has the potential to return almost all rainfall to the atmosphere, allowing as little as 10% to become groundwater. When that filter and sponge capacity is removed due to a disturbance, there may be an increase in both the volume and rate of recharge into a groundwater system from the disturbed area. Recharge rates are also affected by the clay and silt content of the gravel deposit and the direction of the surface drainage with respect to the site.

3. **Lowering of Groundwater Table** - An aggregate operation can lower the groundwater table if excavation occurs at a depth below the average high table. In British Columbia, this situation rarely occurs because most aggregate operating permits prohibit excavation within one metre of the high groundwater table.

   Surface watercourses and groundwater have a complex yet balanced relationship. During low flow periods that relationship can be crucial in ensuring adequate water is supplied to rivers to support aquatic ecosystems. The average depth to the groundwater table is required information in the *Notice of Work and Reclamation application* for sand and gravel pit and rock quarry permit.

Figure CEC - 5: Example water budget for an aggregate operation.


Rain & Storm Water
Diverted
(ditch / berm)
Off site
AGGREGATE OPERATION
Water Supply
Water License/
Water Well
Aggregate Washing
(Optional Activity)
Recycled Water
Collected Storm Water
Settling Pond
Storm Water Run-off
Reclaimed
Solids
silt
clay
Water
pH
TSS
TDS
temp.
Machinery / Equipment
Potential Pollutants
Oil
Fuel
Hydraulic Fluids
Antifreeze
Transient Impacts
Noise
Dust
Traffic
Vibration
Aesthetic
Safety
Oil / Water Separator
Dissipate / Reclamation
Discharge
Water
Oil Products
Environment: Surface Waters
Land Application: Infiltration / Groundwater
Recycled

Water Discharge

Wastewater in British Columbia aggregate operations is generally limited to stormwater, seeping groundwater and surplus process water. The quantity and quality of discharge waters varies considerably by region, and the need for discharge is commonly intermittent on both a day-to-day and seasonal basis. Aggregate permits usually require the installation of perimeter ditches to keep stormwater from entering a gravel pit or rock quarry. Nonetheless, the storm water that collects within the mine site may have to be discharged. Table CEC-6 discusses options for discharging water at aggregate operations.

Table CEC - 6: Discharge options for excess water at aggregate operations.

Discharge Option	Description	Advantages	Disadvantages
Recycle	• re-use for processing.	• provides additional source of water at no cost.	• limited supply • cannot store large volumes. • storage ponds may require an engineering design.
Land Application	• percolation through fields, French drains, infiltration trenches and on-site ponds. • application on land by level spreader (USDA & MSU) or sprinklers.	• mimics natural events, such as flooding. • sediment adds to soil development.	• requires land. • limited by infiltration rates and seasonal saturation of soils. • a summer / seasonal alternative for coastal areas. • will not handle large storm events.
Surface Water Discharge	• discharge to surface water courses.	• cost efficient. • no long term storage required.	• water quality compliance necessary. • requires discharge authorization.

Water Quality

Water quality involves the chemical (pH, TDS) and physical (TSS, turbidity) properties of water in relation to other values such as aquatic life, recreation, agriculture and livestock. Protecting water quality means ensuring that any water discharged from an aggregate operation will meet provincial and federal standards. For protection of water quality, prevention is always preferable to treatment. Table CEC-7 discusses water quality implications for aggregate operations.

Acid Rock Drainage and Quarrying

Metal leaching (ML) and acid rock drainage (ARD) are naturally occurring processes that can have negative impacts on the environment. The primary cause of ML and ARD are elevated concentrations of either sulphide minerals or their weathering products. Acid generation occurs when sulphide minerals are exposed to the weathering effects of oxygen and water, and acidity is produced in the oxidation of sulphur and the hydrolysis of ferric iron. ARD occurs when the resulting acidity and metals are entrained by water. Elevated ML is associated with ARD because of the high solubility of many metals under acidic conditions. For many rock types and environmental conditions, ML will only be significant if drainage pH drops below 6. However, leaching of arsenic, antimony, selenium, zinc and molybdenum may occur under neutral (pH = 7) or alkaline (pH > 7) drainage conditions if the concentrations of these materials in the rock is sufficiently high.

Because these operations usually target unaltered and unmineralized materials, ML and ARD are rarely an issue at aggregate operations, and infrequently at quarry operations . However, the potential for ML and ARD should always be considered both prior to aggregate development and during operations. Predicting ML and ARD usually involves the evaluation of geological characteristics of the materials to be excavated and analytical testwork. Potential indicators include visible sulphide mineralization, visual indications of sulphide oxidation or hydrothermal alteration (rusty or bleached appearance in the materials), and proximity to a known metallic mineral deposit. If any of these indicators are identified, the potential for ML and ARD should be investigated further. In general, materials with the potential for ML and ARD should not be used as a source of aggregate since they may be damaging to the environment, and could result in substantial expenses to the operator for removal costs and associated environmental liability issues. For more information on ML and ARD, contact the Mines Branch of the Ministry of Energy & Mines.

Habitat

Mechanical disturbance at sand and gravel pits and rock quarries has the potential to disrupt wildlife habitat. Awareness of habitat types on the property, such as forest, grassland, etc., and their degree of significance (common, regionally significant and sensitive) can be helpful in planning to minimize disturbances. Habitat protection is preferable to habitat restoration (Murphy 1995). The "Identifying Potential Environmental Impacts" section in the Risk Management Module can aid in habitat identification.

Table CEC - 8 lists general types of environmental and habitat degradation that can occur as a result of sand and gravel pits and rock quarry operations.

Site Specific Environmental Impact Factors

British Columbia's environment ranges from rain forest to desert, and the potential environmental concerns regarding aggregate operations can vary tremendously. For example, storm water management is a significant issue in coastal British Columbia, whereas dust management is a major challenge in the dry Interior. Some other regional factors affecting environmental concerns are:

- rainfall
- temperature
- wind
- habitat diversity
- glacial history
- urban development and agriculture
- soil development
- terrain

Table CEC - 7: **Water quality implications of aggregate operations.**

Water Quality Factor	Description	Units	Sources	Issues	BMPs & Other Measures
PH	measure of relative acidity/alkalinity	range: 0 - 14 average: 6-8 (measured with a pH meter or litmus strips)	• acid rock drainage • limestone • metal leaching	• Sand and gravel deposits will generally not have acid generating constituents. • Quarry rock may have acid generating capabilities.	• Refer to metal leaching & acid rock drainage guidelines.
TSS (Total Suspended Solids)	measure of the weight of very small particulate matter, down to 1/1,000 of a millimetre: sand, silt and clay.	milligrams per litre	• stormwater • seepage • processing • dust suppression • runoff	• TSS at aggregate operations are silts, clays and fine sands that can be picked up by stormwater. • Excess TSS in aquatic ecosystems harm fish and shellfish by causing abrasive injuries and clogging gills, resulting in suffocation. • TSS may also clog small spaces between river bed gravels, eliminating sheltered areas that are important for spawning and immature fish. This clogging also prevents the free flow of oxygenated water, and may cause suffocation and egg mortalities. • TSS decreases visibility for prey species.	• Retention Basin • Settling Pond • Silt Fences • Vegetation Cover • Flocculants (may be toxic to fish, referral MWLAP & DFO required). • Clarification Plants (for large operations)
TDS (Total Dissolved Solids)	measure of soluble pollutants; dissolved matter < 1/1,000 of a millimetre.	milligrams per litre		• There are generally few opportunities for storm water to pick up TDS at aggregate sites. • TDS in quarries may come from metal leaching and calcite veins.	
Turbidity	measure of clarity of water	nephelometric turbidity units (NTU) (measured with a turbidity meter)	• stormwater • seepage • washing • dust suppression • runoff	• Turbidity is detrimental because it reduces water clarity and penetration of light, impairing the ability of aquatic plants to grow and fish to see and find food. • Reduced aquatic plant growth means less available food at the bottom of the food chain and less dissolved oxygen as a by-product of photosynthesis for fish to breath.	• Vegetation Cover • Retention Basin • Settling Pond • Silt Fences
H/C (Hydro-carbons)	petroleum derivatives	milligrams per litre	• spills & leaks • fuelling • storage	• Oil may adhere to fish gills or coat and destroy algae or other plankton. • Hydrocarbons may also pollute groundwater. • Direct toxicities	• Oil/Water Separators • Pollution Prevention
Temperature	temperature	degrees Celsius	• stormwater • stream side vegetation removal • settling pond discharge	• Temperature changes for stormwater are primarily a result of ambient air temperature and sun exposure. • Retaining riparian vegetation will help to maintain cool temperatures for surface watercourses.	• Buffer Zone • Stormwater BMPs
Nitrogen	nitrogen compounds	milligrams per litre	• residue from blasting • over fertilization.	• Increased growth of algae. • Decrease in dissolved oxygen in winter due to algae decomposition. • Toxicity	

Demographic and regional factors, such as local product specification, may also affect environmental concerns. For example, aggregates used in high-rise buildings and bridges will likely require sizing and washing, so more attention should be paid to dust issues and to discharging of sediments. Fill for a parking lot at a recreational site, on the other hand, may not require any processing.

Site-specific concerns may also include property appearance, local groundwater potential and use, and proximity to environmentally sensitive areas.

Conclusion

In planning and operating a pit or quarry, it is important to recognize community and environmental concerns. This handbook presents a range of options to help with the challenge of addressing those concerns appropriate for each site.

Table CEC - 8 Types of habitat degradation from aggregate operations.

Habitat Element	Description	Modules & BMPs
Loss of Topsoil (top layer of soil with roots)	Topsoil can be lost or degraded by: • poor or incomplete salvage, • mixing of topsoil with subsoil or overburden during salvage, • burial under storage areas for overburden and stockpiles, • erosion by wind or water during salvage, stockpiling or reclamation, • improper storage or mechanical compaction and • theft of topsoil from stockpiles.	• Stockpiling Module • Topsoil Management • Vegetation Cover
Loss of Plant Cover	• Plant cover is an integral part of natural habitats, as plants provide food, habitat and protection for insects and other animals. • Vegetation physically protects soil from wind and water erosion. • Vegetation aids in soil development.	• Bioengineering • Vegetation Cover
Wildlife Habitat	• A site assessment can determine whether a site has value as wildlife habitat. • Wildlife habitat and wildlife trees can be disturbed by noise, removal of vegetation, interruption of animal movement and migration corridors, and human presence. • The habitat of previously forested sites near urban areas may be already significantly degraded .	• Buffer Zone • Constructed Wetland • Environmental Timing Windows
Fish Habitat	• Sediment laden surface runoff from a pit or quarry can be detrimental to fish habitat because it may alter the physical aspects and biological productivity of those ecosystems. • Sediments abrade the gill membranes of fish, increasing the risk of suffocation. • Turbidity curtails plant and algae growth, resulting in a food shortage for aquatic species. • Clogging of gravel with fine sediments eliminates sheltered areas important for spawning and fish. • Clogged gravel also prevents oxygenated water from reaching incubating fish eggs and impedes the removal of metabolites (wastes), causing suffocation, poisoning and egg mortality. • High silt loads may inhibit larval, juvenile and adult behaviour, migration and spawning. • Sediment accumulation in semi-closed environments, such as lagoons and marshes, may lead to the partial or complete loss of these habitats.	• Buffer Zone • Check Dams • Constructed Wetland • Ditches • Erosion Control Blanket • Retention Basin • Settling Pond • Silt Fences

Chapter 3

Players, Permits and Legislation

In British Columbia, various Federal, Provincial and local agencies may each have authority to govern aspects of the aggregate industry and require permits. To begin the permit application process, potential operators should contact a Ministry of Energy & Mines - Mines Branch Regional Office to obtain a Notice of Work and Reclamation for Sand and Gravel and/or Rock Quarry form, which serves as a *Mines Act* permit application. In reviewing the Notice of Work, the Ministry of Energy & Mines will refer the application to other applicable Federal and Provincial agencies and initiate a public review if required.

The figures on the two following pages are intended to familiarize operators with the basic framework of Federal and Provincial legislation and local government bylaws, and related permits.

Following the two figures, one-page descriptions of some key government agencies are presented to acquaint operators with the legislation and permits that may apply to aggregate production.

Table PPL - 1: Website links to various levels of government statute sites.

Government	Websites
Federal	http://laws.justice.gc.ca/en/index/index.html
Provincial	http://www.qp.gov.bc.ca/statreg/
Local Govt. Links	http://www.civicnet.gov.bc.ca/members/municipalities/index.shtml

Copies of legislation can be purchased through official sales agents for the Federal, or Provincial governments, or generally can be viewed over the Internet at a central website.

Local governments regulate activities through bylaws. These bylaws can be viewed at regional district or municipal offices and are available on local government Internet sites.

An acronym key for government agencies can be found in Appendix 4.

BC Aggregate Regulatory Framework

A partial description of the legislation that applies to aggregate extraction in British Columbia. Refer to Appendix 4 for a list of acronyms.

FEDERAL

DFO

Fisheries Act

EC

Canadian Environmental Assessment Act

Fisheries Act (Section 36)

Canadian Environmental Protection Act

Migratory Birds Convention Act

Canada Wildlife Act

International River Improvements Act

CG&TC

Navigable Waters Protection Act

PROVINCIAL

MEM

Mines Act

MCAWS

Local Government Act

MWLAP

Wildlife Act

Waste Management Act

LWBC

Land Act

LRC

Soil Conservation Act

Forest Land Reserve Act

Agricultural Land Reserve Act

MOT

Highway Act

MOF

Forest Act

Range Act

Forest Practices Code Act

MSRM

Heritage Conservation Act

Water Act

EAO

Environmental Assessment Act

LOCAL GOVT

Regional Districts & Municipalities

- *Local Govt. Act*
- *Soil Conservation Act*
- *Memorandums of Agreement*
- Official Community Plans
- Bylaws (examples)
  - ✱ Soil Removal
  - ✱ Zoning
  - ✱ Subdivision & Servicing
  - ✱ Development
  - ✱ Temporary Industrial
  - ✱ Noise
  - ✱ Tree Retention
  - ✱ Commercial Vehicle
  - ✱ Business Licenses

OTHER GOVT

First Nations

(Consultation)

BC Aggregate Permitting Framework

A partial description of permits, approvals, licenses and certificates required for aggregate extraction in British Columbia. Refer to Appendix 4 for a list of acronyms.

FEDERAL

DFO
- Authorization

EC
- Environmental Assessment
- *Migratory Bird Convention Act* permits
- *Fisheries Act*, Section 36 authorization

CG&TC
- Works impacting navigable water

PROVINCIAL

MEM
- *Mines Act* Permit

MWLAP
- Waste Discharge Permit

LWBC
- Crown Tenure

LRC
- ALR Approval
- FLR Approval

MOT
- Highway Access

MOF
- Special Use Permit
- Road Permit
- Free Use Permit
- Licence to Cut
- Burning Permit

MSRM
- Water authorization
- *Heritage Conservation Act* Permit

EAO
- Environmental Assessment
- Project Approval Certificates

LOCAL GOVT.

Regional Districts & Municipalities
- Official Community Plans
- Zoning Regulations
- *Soil Conservation Act* Permit
- Subdivision & Servicing
- Other Bylaws & Permits
  - ✱ Development
  - ✱ Building
  - ✱ Soil Removal
  - ✱ Temporary Use Permits
  - ✱ Runoff Control
  - ✱ Tree Retention
  - ✱ Signs
  - ✱ Burning
  - ✱ Noise
  - ✱ Commercial Vehicle
  - ✱ Business License
  - ✱ Heritage Conservation

OTHER GOVT.

First Nations
- Consultation

Fisheries and Oceans Canada (DFO)

Agency	Fisheries and Oceans Canada
Authority	*Fisheries Act; Canadian Environmental Assessment Act*(CEAA)
Mandate Specific to Aggregate Operations	To prevent negative impacts of projects and activities that have the potential to alter, disrupt or destroy fish habitat. • Section 35 of the *Fisheries Act* prohibits the harmful alteration, disruption, or destruction of fish habitat. It applies to all fish habitat in Canada including non-salmon freshwater habitats. • Section 32 of the *Fisheries Act* prohibits the destruction of fish by any means other than fishing. • Section 36 prohibits deposition of substances deleterious to fish. • Section 20 prohibits obstruction of fish movement. • Section 30 requires screening of all water intakes. • The Policy for the Management of Fish Habitat (Fisheries and Oceans Canada, 1986) outlines the Net Gain of Fish Habitat Policy Objective and provides direction for interpreting the broad powers mandated by the *Fisheries Act*.
Role in Aggregates Administration	• Case-by-case evaluations, conducted prior to project implementation, normally initiated through MEM referral. • Impact avoidance by redesign and/or relocation is pursued as the first priority via the project planning process.
Permits, Approvals, Licenses and Certifications Issued	• Subsection 35(2) Authorization of unavoidable harmful alteration, disruption, or destruction of fish habitat. • Contains legally binding habitat compensation requirements, monitoring, maintenance and financial security obligations.
Application Requirements	Appropriate documentation and studies required for assessing each proposed project.
Application Process	• Referral process is coordinated with other regulating agencies. • Subsection 35(2) Authorizations require a review under the *Canadian Environmental Assessment Act*.
Compliance Monitoring	• Periodic inspections by habitat officers. • Assessment of constructed (compensation) habitats where applicable.
Enforcement Provisions	• Inspector's orders under Section 38(6) of the *Fisheries Act*. • Charges under the *Fisheries Act*. • Conviction under the *Fisheries Act* may result in a fine, imprisonment or both, as well as recovery of costs.

Contact Information	For General Enquiries, please contact: Director, Habitat and Enhancement Branch, Fisheries and Oceans Canada, 360-555 W Hastings St., Vancouver BC V6B 5G3, or the local DFO office. Website: http://www.pac.dfo-mpo.gc.ca
Additional	Fisheries and Oceans Canada includes the Canadian Coast Guard, which administers the *Navigable Waters Protection Act*. The provisions of this *Act* may regulate aspects of aggregate operations, including transport of aggregates.

Environment Canada (EC)

Agency	Environment Canada
Authority	*Canadian Environmental Assessment Act (CEAA),* *Fisheries Act (Section 36),* *Canadian Environmental Protection Act,* *Migratory Birds Convention Act,* *Canada Wildlife Act and* *International River Improvements Act.*
Mandate Specific to Aggregate Operations	Through these acts, Environment Canada: • sets out the Federal environmental assessment process, • prohibits the deposition of deleterious substances into waters frequented by fish, • regulates toxic substances, nutrients and pollution at Federal facilities, international air pollution and ocean dumping, • facilitates the conservation and protection of migratory birds and their habitat, • facilitates the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and • regulates the alteration of river flows and water levels across the international boundary. Environment Canada also: • Through the Federal Policy on Wetland Conservation, promotes the maintenance of wetland values across Canada.
Role in Aggregates Administration	Environment Canada initiates environmental assessment process for operations that fall under the *CEAA* Comprehensive Study List Regulations 3.18 (see Part V): "(i) a stone quarry or gravel or sand pit with a production capacity of 1,000,000 t/a or more".
Permits, Approvals, Licences and Certifications Issued	Activities related to the legislative mandate of Environment Canada may require permits. For example, a permit to alter the nest, egg or shelter of a migratory bird may be issued under the *Migratory Birds Convention Act.*
Contact Information	For General Enquiries, please contact: Environmental Assessment: (604) 666-0901, 224 West Esplanade, North Vancouver, BC V7M 3H7. Website: http://www.ec.gc.ca/envhome.html

Ministry of Energy and Mines (MEM)

Agency	British Columbia Ministry of Energy and Mines, Mines Branch (MB)
Authority	*Mines Act*, Health, Safety and Reclamation Code for Mines in BC
Mandate Specific to Aggregate Operations	• Pits and quarries are defined as mines and are regulated under the *Mines Act*.
Role in Aggregates Administration	To manage mines for: • safety and health of mine workers and public, • minimal environment impacts and • reclamation of site into sustainable and productive end use.
Permits, Approvals, Licences and Certifications Issued	• *Mines Act* Permit. • Shiftboss, mine rescue, explosives magazine, blasting certificate, etc. • Cutting licences on Crown Land. • Road use agreements for activities on Forest Service Roads (FSR).
Application Requirements	• Notice of Work and Reclamation Program for a Sand & Gravel/Quarry Operation (NoW), complete with description of proposed work, environmental protection plan, reclamation plans, maps, and cross sections.
Application Process	1. Apply for *Mines Act* Permit, using a NoW. 2. MEM reviews permit application and refers it to affected agencies. 3. Public review if required. 4. MEM decides whether to issue a permit and if a permit is to be issued places conditions of operation on permit, including reclamation security amount. 5. MEM issues *Mines Act* Permit.
Compliance Monitoring	• Regular inspections by Inspectors of Mines to assess compliance with *Mines Act*, Code and permit conditions. • Inspector must issue Inspection Reports, which may order a remediation, suspension or closure.
Enforcement Provisions	1. Orders 2. Cancellation of permit 3. Seizure of security 4. Injunction 5. Fine or imprisonment
Contact Information	For General Enquiries, please contact: (250) 952-0471 Website: http://www.em.gov.bc.ca/

Ministry of Forests (MOF)

Agency	British Columbia Ministry of Forests
Authority	*Forest Act* *Forest Practices Code of British Columbia Act*
Mandate Specific to Aggregate Operations	To regulate timber harvesting activities on Crown lands through the *Forest Act* and on private land through the *Forest Practices Code of British Columbia Act* and Regulations.
Role in Aggregates Administration	• Management of timber resources on Crown land. • Authority and guidance on production of granular material for resource roads.
Permits, Approvals, Licences and Certifications Issued	• Special Use Permit (SUP) • Road Permit • Free Use Permit • Licence to Cut • Burning Permit
Application Requirements	Variable, depending on permit.
Application Process	Apply through MEM NoW referral process or contact MOF directly.
Compliance Monitoring	1. MOF staff from Compliance and Enforcement Branch (C&E) inspect for compliance. A specified time period is given to bring deficiencies up to code requirements. 2. Follow-up inspection to confirm specified remedial work completed.
Enforcement Provisions	*Forest Practices Code of British Columbia Act* and Regulations
Contact Information	District Manager of forest district in which SUP is approved or MOF pit is developed.

Minister of Sustainable Resource Management (MSRM)

Agencies under Minister of SRM	Ministry of Sustainable Resource Management Land and Water British Columbia (LWBC) Environmental Assessment Office (EAO) Land Reserve Commission
Authority	*Land Act, Water Act, Heritage Conservation Act Environmental Assessment Act(EAA),* Forest Land Reserve Act and *Agricultural Land Reserve Act*
Mandate Specific to Aggregate Operations	To provide Provincial leadership toward achieving sustainable development of the Province's land, water and resources, including: • Allocation and rental of water resources, • Allocation of Crown land for quarrying and allocation of Crown aggregate resources, • Collection of Crown land use rent and aggregate resource royalties, • Protection and conservation of heritage property and • Environmental assessment of large aggregate or quarry proposals.
Land Act	Application process for Crown land applications: 1. Apply to LWBC field office for *Land Act* tenure; 2. LWBC review and referral to other agencies and local govt.; advertising of application by applicant; 3. Land use decision by LWBC (Approval/Disapproval); 4. LWBC issuance of *Land Act* tenure. The LWBC website for aggregate is: http://lwbc.bc.ca/applying_for_land/aggregates.htm
Water Act	• The *Water Act* authorizes the use, diversion and storage of water. For long-term use a licence is required, but for shorter-term use (not exceeding 12 months), a Section 8 approval is all that is required. • The *Act* also authorizes changes (work) in and about a stream. However, regulation allows that an approval under the *Act* is not required for routine works provided that conditions and requirements under the regulation are met. This includes notification of the MWLAP's Regional Habitat Officer through a notification form and meeting the terms and conditions of the Habitat Officer, and seeking approval from the Federal government under the *Fisheries Act*. For major works (diversions, rip rapping), proper drawings and a Section 9 approval is required, with Federal approval as well.

Environmental Assessment Act (EAA)	The Province's *Environmental Assessment Act*, administered by the Environmental Assessment Office (EAO) applies to very large aggregate proposals seeking a project approval certificate. The Environmental Assessment Reviewable Projects Regulation specifies reviewable projects as those with a production capacity of 500,000 or more tonnes per year, 1,000,000 or more tonnes over less than four years or an increase of 35% in the size of the disturbed area. The EAO's website http://www.eao.gov.bc.ca/ details the environmental assessment process.
Heritage Conservation Act	Heritage Permits are issued under the *Heritage Act* authorizing a person to undertake actions affecting heritage objects.
Compliance Monitoring	• *Land Act* - Submit an annual statutory declaration of volume of aggregate material removed and certified cheque for royalty payment. • Periodic compliance review under *Water Act*, *Environmental Assessment Act* and the *Heritage Act*.
Enforcement Provisions	Enforcement provisions are located within and are specific to the *Land Act, Water Act, Heritage Conservation Act,* and *Environmental Assessment Act*
Contact Information	For Crown Land Application and Tenure Information, contact the appropriate LWBC Inc field office. Website: http://www.bcal.bc.ca/contact.htm http://lwbc.bc.ca/applying_for_land/aggregates.htm *Water Act* - for authorization for storage, use or diversion of water, and work in and about a stream, contract regional offices of MSRM. *Heritage Conservation Act* - for heritage site enquiries, contact Archaeology Planning & Assessment BC, MSRM, Victoria. Website: http://www.archaeology.gov.bc.ca *Environmental Assessment Act* - for large aggregate or quarry proposal contact the Environmental Assessment Office in Victoria. Website: http://www.eao.gov.bc.ca.

Ministry of Water, Land and Air Protection (MWLAP)

Agency	British Columbia Ministry of Water, Land and Air Protection
Authority	*Waste Management Act, Wildlife Act, Water Act,* and *Fish Protection Act.*
Mandate Specific to Aggregate Operations	The Ministry of Water, Land and Air Protection (MWLAP) is responsible under the *Ministry of Water, Land and Air Protection Act* for the management, protection and conservation of all water, land, air, plant life and animal life.
Waste Management Act	• The *Waste Management Act* authorizes discharges into the environment. Authorizations take the form of waste management approvals and permits. • Introduction of deleterious substances into the environment, intentionally or unintentionally, without a valid authorization may result in charges under the *Act*. Examples of unauthorized discharges potentially occurring on an aggregate property include discharges of sediment or dust, as well as a fuel (hydrocarbon) spill. • Under the *Act*, the Ministry may order construction of works to prevent unauthorized discharge or achieve compliance with permits or approvals, and may also require necessary monitoring or studies.
Water Act* and *Fish Protection Act	• Fish habitat is protected primarily through the Federal *Fisheries Act* administered by Fisheries and Oceans Canada (DFO). However, since the Province owns the water and most of the land in BC, it can indirectly protect fish and fish habitat through its legislation, primarily the *Water Act* and, when fully enacted, the *Fish Protection Act*. • In some local jurisdictions the MWALP has entered into intergovernmental agreements (Memoranda of Agreement) with local jurisdictions and DFO for the purpose of protecting the environment through a coordinated approach.
Reclamation	• For reclamation purposes, security requirements under the *Waste Management Act*, *Wildlife Act* and *Fish Protection Act* are, by understanding with the Ministry of Energy and Mines, included in the *Mines Act* permit.
Contact Information	• Applications and advice regarding authorizations under the above legislation can be obtained at the Ministry's regional offices. • MWLAP website: http://www.gov.bc.ca/wlap/.

Ministry of Transportation (MOT)

Agency	Ministry of Transportation
Authority	*Highway Act*
Mandate Specific to Aggregate Operations	Section 54(1) of the *Highway Act* prohibits construction or use of a "private road, entrance, way, gate or other structure or facility as a means of access to a controlled access highway" without a permit.
Role in Aggregates Administration	The Ministry is the province's largest user of aggregates. It both purchases aggregate from producers and operates its own pits. Aside from Section 54(1) permits, the MOT's role is essentially non-regulatory.
Permits, Approvals, Licences and Certifications Issued	• Road access permit. • For Ministry of Transportation pits only: – Designate Pit Manager – Provide pit resource development plan – Conduct rehabilitation of pits
Application Process	Road access permit application process normally initiated through MEM referral.
Compliance Monitoring	Regional Gravel Resource Manager - monitors all work operations
Enforcement Provisions	Ministry contracts
Contact Information	For General Inquiries, please contact: Senior Geoscientist, Engineering Branch, Ministry of Transportation, 4B-940 Blanshard St., PO Box 9850, Stn Prov Govt, Victoria, BC V8W 9T5 or phone (250) 387-7702, fax (250) 356-7798
Additional Information	For Specific Pit Information, please contact: Vancouver - (604) 501-8317 Kamloops - (250) 828-4882 Nelson - (250) 354-6682 Prince George - (250) 565-6677 Terrace - (250) 615-3952 Nanaimo - (250) 390-6240

Local Government

Agency	Local Government • Regional Districts • Municipalities
Authority	*Local Government Act, Soil Conservation Act*
Mandate Specific to Aggregate Operations	To represent the interests and respond to the needs of communities by providing services, managing public assets and fostering their current and future economic, social and environmental well being. Local Governments may adopt growth strategies or Official Community Plans that guide decisions on land use management, and may adopt various regulatory bylaws to implement plans and/or establish permit requirements.
Role in Aggregate Administration	• Issue permits and processes applications to remove soil and/or place fill on land within the Agricultural Land Reserve (ALR) pursuant to the *Soil Conservation Act*. • Respond to referrals from the Ministry of Energy and Mines regarding mines permit applications to provide an assessment of the consistency of the proposed operation with the community plan, zoning regulations and development permit area guidelines. • Establish zones for aggregate uses (e.g., processing) and, within zones, regulate: – The use of land, buildings and structures, – The density of the land use, buildings and structures, – The siting, size and dimensions of buildings, and structures and uses that are permitted on the land, and – The location of uses on the land and within the buildings and structures (*Local Government Act* s. 903).
Permits, Approvals, Licences and Certifications Issued	• Soil removal and deposit permits for land in the ALR pursuant to the *Soil Conservation Act*. • Local governments may enact soil removal and deposit bylaws that regulate or prohibit the removal and deposit of soil. These bylaws may establish different regulations and prohibitions for different areas. Fees may be charged for these permit applications. • Local Governments may consider the issuance of temporary use permits for specific land uses not permitted in a zone.
Application Requirements	Local Governments: • Review applications for consistency with Official Community plans, development permit guidelines, zoning and other land use regulations, policies and regulations of senior levels of government, and environmental and community impacts; • Submit all appropriate documentation and studies requiring assessment • May hold public information meeting.

Application Process	1. Within the ALR or Forest Land Reserve (FLR), apply to the Local Government. 2. Applications will be forwarded to the Land Reserve Commission (LRC) for a decision. 3. If approved by LRC, application is forwarded to Local Government for review and consideration of approval 4. Local Government issues permit.
Compliance Monitoring	- Monitoring of local government regulations and permit compliance under *Soil Conservation Act* by Bylaw Enforcement Officer. - Local Government answers public enquiries and refers issues or concerns to appropriate agencies as necessary.
Enforcement Provisions	- Enforcement of permits to remove soil and/or place fill on land in the ALR is subject to ticketing authority or court action, enforcement on non-ALR lands for activities contrary to local government regulations ultimately could result in court action.
Contact Information	For general inquiries, contact: Local Governments listed in the government sections of telephone directories or on Civicnet @ http://www.civicnet.gov.bc.ca/.
Additional Information	Local Governments may have prepared independent land use studies or aggregate studies as part of the implementation of plans or bylaws. Official Community Plans often contain policies related to aggregate management and may show the location of known or active sand and gravel pits.

PART II

Chapter 4

Mine Planning

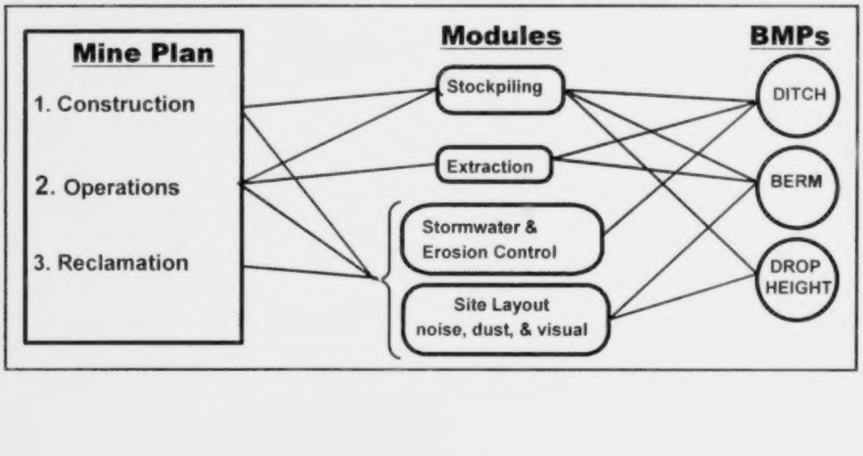
This chapter contains basic advice on mine planning, map preparation and coordination of aggregate production. It also includes non-production related topics such as noise, dust and traffic. It describes in general terms how to use the modules presented in Chapter 5 of this manual, and contains a section on use of maps in planning.

Preparing a mine plan may be a significant undertaking involving engineering reports, market analyses, community consultation and environmental studies. A mine plan may address issues related to:

1. resource identification (exploration)
2. market analysis and business planning
3. access to land
4. environmental management
5. community consultation
6. permitting processes
7. operations
8. reclamation and post extraction land use

Modular Approach to Mine Planning

Figure MP - 1: Illustration of a modular approach to mine planning


Mine Plan
1. Construction
2. Operations
3. Reclamation
Modules
Stockpiling
Extraction
Stormwater & Erosion Control
Site Layout noise, dust, & visual
BMPs
DITCH
BERM
DROP HEIGHT

The following modules address many aspects of managing an aggregate operation, with each module containing helpful planning and BMP suggestions.

Table MP - 2: Mine planning modules and their sections

MODULES & Sections	Abbreviation
1. EXTRACTION	EM
2. PROCESSING	PM
3. STOCKPILING	SM
4. TRAFFIC	TM
5. STORMWATER & EROSION CONTROL	SECM
6. BY-PRODUCT & WASTE MANAGEMENT	BWM
7. SITE LAYOUT • Noise • Dust • Visual Landscape	SLM
8. RISK MANAGEMENT • Emergency And Spill Response • Employee Training • Community Relations • Identifying Potential Environmental Issues	RMM
9. BMP MONITORING	BMM

Modules can be selected as required by the location, size and complexity of the operation to ensure that priority areas are handled appropriately, and to make the overall mine planning process less daunting.

Each module includes a discussion and planning and BMP suggestions. All modules follow a similar format for ease of use. The general format is:

1. common concerns
2. discussion of the topic
3. suggested planning and BMPs options

Mine Planning - A Four-Step Process

Because every gravel pit and rock quarry is unique, each will have a unique mine plan. Nonetheless, there are four common steps that can be applied to most aggregate operations in preparing formal mine plans or reviewing existing operations.

Step 1 - Scope	• Define the project. • Set goals.

A mine plan should be the blue print for an aggregate operation. Scoping out a mine plan involves determining what needs to be done and setting out goals for the operation. Will the product be pit run or high quality screened and washed aggregate? Will a quarry produce riprap or Superpave™ aggregate? There are many factors that will affect the answers to these questions. A mine plan should be flexible, technically competent, business smart and respectful of the community and the environment.

Step 2 - Research	• Gather information for turning goals into detailed plans.

Research helps to flesh out the goals into plans. Table MP - 3 lists some helpful types of mine planning information and may be a good starting place for research. The Identifying Potential Environmental Issues component in the Risk Management Module also has references to numerous information sources. Legal information requirements for formal mine plan applications are laid out in the *Mines Act*, the Health, Safety and Reclamation Code for Mines in British Columbia, and the *Sand and Gravel and/or Rock Quarry Notice of Work and Reclamation* form. Further information may be required by other Provincial or Federal acts or local government bylaws. Those mining specific documents, other statutes and local government community plans and bylaws set out the information parameters that allow decision makers to assess mine safety and community and environmental impacts.

Step 3 - Planning	• Plan out the details.

Mine planning involves making decisions. A good mine plan explores all of the options within various constraints (i.e. economic and technical feasibility, compatibility with adjacent land uses, compliance with legal requirements, etc.) to determine how a mine will be developed and operated. Maps help to visualize a mine plan. They are essential planning tools for developing any aggregate property, and a number are required for a *Mines Act* permit application. Basic advice for constructing plan maps is presented later in this chapter.

Step 4 - Assembly	• Put all the pieces together.

The final step in the mine planning process is to assemble the information and concepts in a comprehensive plan. The information could include advice from pertinent modules in this handbook as well as the various documents (engineering reports, environmental and community reports, etc.) submitted in support of a *Mines Act* permit application.

Table MP - 3: Helpful mine planning information

INFORMATION CATEGORY	INFORMATION (examples in brackets)	SOURCES: Where to find detailed requirements or information
Legal	• Tenure (property title, lease) • Company name • Site identification (lot numbers) • Jurisdiction (municipal, Crown, etc.)	• Internal / Corporate • Land and Water BC • Local Government • Land Title Office
Administrative	• Applicant's name • Contact information (address, phone) • Application type (pit, quarry, new, modified Notice of Work and Reclamation)	• Internal / Corporate • *Mines Act* • Health, Safety & Reclamation Code
Geological	• Type of deposit • Extent of deposit • Grade, quality • Soils requiring conservation • Topography and drainage	• Consultants • Lab results • Market standards (CSA, BCH, ASTM, AASHTO, CalTrans)
Engineering	• Slope design • Blasting • Facility equipment (extraction, processing, transportation)	• Internal / Corporate • Equipment vendors • Health, Safety & Reclamation Code
Transportation	• Onsite haul roads • Onsite loading requirements • Offsite routes	• Internal / Corporate • Health Safety & Reclamation Code • Ministry of Transportation • Local governments
Operations	• Production rates / scheduling • Products	• *Mines Act* • Health, Safety & Reclamation Code • Internal / Corporate

Environmental	• Habitat
	  • Fish and wildlife habitat present
	  • Red & Blue listed species in area
	• Water
	  • Average rainfall
	  • Potential site rainfall volumes
	  • Water supply
	  • Groundwater depth & quality
	  • Creeks, streams and other water bodies and courses
	• Vegetation
	  • Inventory
	• Air quality
		• Ministry of Sustainable Resource Management
		• BC Conservation Data Centre (CDC)
		• Fisheries & Oceans Canada
		• Environmental Atlases
		• Consultants
		• Ministry of Water, Land and Air Protection - web pages and regional offices
		• Land Reserve Commission
		• Ministry of Agriculture, Food and Fisheries
		• Local government offices
		• *Mines Act & Health, Safety & Recln Code*

Community	• Official Community Plans • Zoning, bylaws & other regulations • Adjacent land use, easements, statutory right-of-ways, covenants • Site history • Noise and dust receptor sensitivity	• Local government • BC Heritage • Ministry of Community, Aboriginal and Women's Services
Reclamation	• Decommissioning specifications and reclamation standards	• *Mines Act* • *Health, Safety & Reclamation Code* • Zoning defined within Official Community Plan or Growth Strategies

Table MP - 4: Mine plan activity and module worksheet

MODULES Activity	EM	PM	SM	TM	SECM	BWM	SLM			RMM					
	Extraction	Processing	Stockpiling	Traffic	Stormwater & Erosion	By-product & Waste	Noise	Dust	Visual Landscape	Risk Management	Emergency & Spill Resp.	Employee Training	Community Relations	ID Environmental Issues	BMP Monitoring
SITE PREPARATION															
Timber clearing / Grubbing			✓		✓	✓	✓		✓		✓	✓		✓	✓
Topsoil / Overburden salvage			✓		✓	✓	✓	✓	✓		✓	✓		✓	✓
Construction/Utilities/Services					✓	✓				✓	✓	✓			✓
Sediment Control	✓				✓							✓		✓	
OPERATIONS/EXTRACTION															
Haul roads	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓			✓
Extraction	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Drilling and blasting	✓	✓					✓	✓		✓	✓	✓		✓	✓
H/C storage, handling, disposal	✓	✓			✓	✓				✓	✓	✓		✓	✓
Mobile equipment operations	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
Waste management	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓
Site entrance / Exit		✓	✓	✓	✓			✓	✓				✓		✓
Safety & security	✓			✓						✓		✓	✓	✓	✓
Stormwater / Erosion control	✓		✓		✓	✓						✓			✓
Settling ponds	✓	✓			✓	✓					✓	✓			✓
Water exfiltration/Discharge	✓	✓			✓	✓					✓	✓		✓	✓
PROCESSING & HANDLING															
Screening / Crushing		✓				✓	✓	✓	✓			✓			✓
Washing		✓			✓	✓			✓		✓	✓			✓
Material separation / Blending		✓	✓				✓	✓				✓			✓
Conveyor operations		✓	✓				✓	✓	✓		✓	✓			✓
Stockpiling / Material handling		✓	✓		✓	✓		✓	✓			✓			✓
Loading		✓	✓	✓			✓	✓	✓		✓	✓			✓
RECLAMATION															
Decommissioning	✓				✓	✓			✓		✓	✓	✓	✓	✓
Grading / Drainage alteration	✓				✓	✓		✓				✓	✓	✓	✓
Re-vegetation	✓				✓	✓			✓			✓	✓	✓	✓
OFF SITE IMPACTS															
Traffic		✓		✓			✓	✓					✓		✓
Dust	✓			✓				✓	✓			✓	✓	✓	✓
Noise	✓	✓		✓			✓					✓	✓	✓	✓
Viewscapes	✓	✓	✓	✓	✓				✓				✓		✓

Maps - The Key Planning Tool

Maps are the key tool for developing a mine plan. In order to clearly illustrate an operation, they should be of appropriate size and scale. Maps can range from pen and ink annotations on pre-printed government topographic maps, to digital products on customized and surveyed base maps. Basic information that is commonly required on maps is illustrated in Table MP - 5.

Maps can be drawn to show almost any aspect of an aggregate operation and are specifically recommended in several of the modules in this handbook. The scale, complexity and location of an aggregate operation will determine how many, and what types of maps should be prepared. Depending upon the detail required, some maps may be combined. Table MP - 6 lists some common types of aggregate mine maps.

The Ministry of Energy and Mines' Sand and Gravel / Quarry Notice of Work and Reclamation Program form outlines the Ministry's specific map requirements. Applications for other necessary permits or authorizations may also have specific map requirements.

Common Map Features

Some common features that should be present on all aggregate permit application maps are:

- Boundaries of the requested permit area,
- Elevations and contours,
- Drainage patterns and names,
- Jurisdictional boundaries and names of local governments,
- Property boundaries, dimensions and lot numbers,
- Roads, access points, railroads, utility lines, right-of-ways and easements with complete names,
- Current land uses including buildings and structures, locations of wells, park lands, and other artificial features,
- Boundaries and dimensions of the areas to be disturbed and mined,
- Environmentally sensitive areas such as streams, lakes, wetlands, coastlines, coastal bluffs, older forests, riparian vegetation and woodlands (Note: some local governments have Environmentally Sensitive Areas Atlases available to the public), and
- Adjacent land uses.

Table MP - 5: Basic and other commonly required map elements

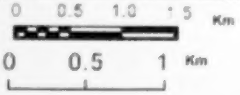
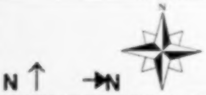
Map Element	Description	Examples
Basic Map Elements		
Map Scale	Scale tells you the relationship between the size of features on the map and their actual size on the ground. Applications generally tell you what scales are required for each map.	**Common Scales** • Location maps - 1:250,000 / 1:50,000 • Local features map - 1:20,000 (TRIM) • Site map - 1:500 to 1:1,000 Note: Cross sections should have the same vertical and horizontal scales.
Graphic Bar Scale	Graphic scales are like a ruler that can be used to measure the size of features on the map, and will remain accurate even if the map is reduced or enlarged.	
North Arrow	All maps must show the direction of north. A north arrow helps to orient the map during field use.	
Legend	Defines all symbols and patterns used on the map.	
Title Block	May contain information such as: • Title of Map • Permit/Application Number • Name & Address of Permittee • Signature of Engineer • Map Number • Date of Map	
Topographic Contours	Lines of equal elevation, illustrating the topography or the lay of the land for the map area.	• Contour intervals are determined by scale and detail required. • State contour interval in legend.
Boundaries	• Permit area boundary • Mining boundary • Local govt. boundaries • Property lines, etc. • Dimensions	
Other commonly required map elements		
Watercourses, Ponds and Wetlands	All streams, rivers, wetlands and ponds should be indicated on the maps.	
Environmental Features	• coastlines & coastal bluffs • old growth forests	Note: Some local governments have Environmentally Sensitive Areas atlases available to the public.

Table MP - 6: **Common types of aggregate permit application maps**

Common Types of Maps in a Mine Plan	***Notice of Work and Reclamation Map****
Site Location/Access Map	Schedule A1*
Local Features Map	Schedule A2*
Land Title Map	Schedule A3*
Mineral Tenure Map	Schedule A4
Terrain/Geology and Terrain Stability Map	Schedule A5
Mine Plan/Extraction Map	Schedule A6*
Cross Section of Proposed Development	Schedule A6*
Reclamation/Post Extraction Land Use Map	
Module Maps (Dust, Noise, etc.)	

* Indicates required by Notice of work and Reclamation Program

Site Location/Access Map

A Site Location/Access Map shows the regional setting of the site and how to reach the site by road. This type of map is commonly presented on a letter size page. Some Site Location/Access Maps also incorporate copies or overlays of air photos to give a bird's eye view of the regional setting.

Local Features Map

A Local Features Map shows background information for the site, such as the lay of the land before extraction begins. Land use, archaeological or environmental features could also be illustrated on this map. Similarly to the Site Location/Access Map, air photos can be combined with contours to convey the relationship between the features of the property with the surrounding area.

Additional local features:

- water wells
- archaeological sites
- environmental features
- test pit & test drill locations
- vegetation

Mine Plan/Extraction Map

Mine Plan/Extraction Maps show how the deposit will be mined. Applicants may choose to produce one for each phase of extraction or one for each stage of completion (e.g., at 25%, 50%, 75% and 100%). Alternatively, they may choose to illustrate all phases on a single map. Mine plan/extraction maps should be accompanied by cross sections showing water table information and, in the case of quarry plans, geological structure details.

Additional Mine Plan/Extraction Map features:

- 2 metre contours
- Permanent boundary markers
- Proposed access roads
- Setbacks and berms
- BMPs (note codes in top left hand corner of BMPs for this use)
- Stockpile areas
- Primary crusher and processing plant
- Stormwater and erosion control features (i.e., ditches, settling ponds, etc.)

Reclamation/Post-Extraction Land Use Map

Sand and gravel pits and rock quarries in British Columbia may be reclaimed for agriculture, forestry, wildlife habitat, fish habitat, recreational, residential or industrial uses. Post-extraction land use may be determined by an official community plan (see Risk Management Module). An appropriate map should be prepared showing the configuration of the site upon completion of mining and reclamation.

The key element of this map, which should include a cross section, is the proposed post-mining lay of the land, or grade. For ease of reference, the map should be of the same scale as the Local Features Map, or at a scale convenient for the post-extraction use of the site. For some situations, this map could also be the final mining stage or the 100% mine plan/extraction map. For reclamation details, refer to the *Reclamation and Environmental Protection Handbook for Sand, Gravel and Quarry Operations in British Columbia.* It is currently available from the Ministry of Transportation.

Additional reclamation/post-extraction land use features:

- Reclaimed drainage patterns
- Depth of replaced overburden, rock, and topsoil
- Revegetation plans, if applicable

Chapter 5

Planning Modules

page

5-1 EXTRACTION MODULE - EM 38

5-2 PROCESSING MODULE - PM 46

5-3 STOCKPILING MODULE - SM 51

5-4 TRAFFIC MODULE - TM 54

5-5 STORMWATER & EROSION CONTROL MODULE - SECM 59

5-6 BY-PRODUCT & WASTE MODULE - BWM 65

5-7 SITE LAYOUT MODULE - SLM 72

5-8 RISK MANAGEMENT MODULE - RMM . 90

5-9 BMP Monitoring Module - BMM 110

5 - 1 EXTRACTION MODULE - EM

Common Concerns: Extraction

Extraction is a core activity for all aggregate operations. It is important that extraction be coordinated with processing in order to deliver material at an optimum size and rate from the working face into the processing stream (i.e., crushing or sizing facilities) or directly to the load-out facilities (Bowers et al. 1990). In additional, extraction should be coordinated with non-production considerations such as noise and dust reduction. Documentation of extraction planning in a formal extraction plan is also an application requirement for a *Mines Act* permit (Notice of Work & Reclamation for a Gravel Pit or Quarry) and may be required for local government soil removal permits.

The location of the working face and the extraction technique used will affect an operation's noise and dust emissions, visual impact and stormwater management, and may limit options for reclamation and post-extraction land uses. Adequate extraction planning may also help to avoid expensive and time-consuming problems once mine development proceeds.

This module focuses on coordinating extraction activities with the non-production considerations of an operation (refer to Table EM - 2), and will offer only general technical advice. Advice for the technical components of extraction is readily available from publications such as *The Aggregate Handbook* of the National Stone, Sand and Gravel Association in the USA, and various trade journals and magazines.

Extraction Planning

For extraction planning, aggregate operations may choose to have both long-term (mine-life) and short-term plans, and production related and non-production related plans as well.

Mine-Life Extraction Planning

Mine-life extraction planning details the overall extraction scheme for the entire deposit, and major events in the life of the mine. It describes the mining strategy and coordinates production with other components and activities such as noise reduction and processing activities. Mine-life planning may also include major capital expenditures or equipment purchases.

Short-Term Extraction Planning

Short-term extraction planning details expected activities over a one or two-year period. For example, phased extraction planning provides detail for one phase of a proposed operation. This type of planning can also specify operational direction on equipment selection, surface stripping areas, road developments and detailed extraction activities.

Production and Non-Production Related Planning

Production and non-production related extraction planning is discussed in Tables EM-1 & EM-2. Following these tables are some key pointers for both production and non-production related considerations. Table EM-3 relates extraction components to other modules and BMPs in this handbook.

Table EM - 1: Production related extraction planning considerations.

Production Related Considerations of Extraction Planning	
Pit/Quarry Size & Shape	• Pit/quarry width, length, extractable reserves and viability of phased mining will be determined by the deposit's shape and size, the topography and the quarry rock's structure.
Depth of Excavation	Factors which may limit the depth and shape of the excavation pit or face include: • depth to the top and bottom of the resource, • depth to the top of the groundwater table, • site steepness and lay of the land, and • the material competency or rock structure to maintain slope stability.
Phased Mining Option	• Some deposits can be mined in phases. • Determining factors may include: depth, thickness and shape of the deposit, the topography of the site, and the need to blend material (requiring a separate face for each type of product). • Phased mining can have numerous benefits for reclamation, environmental management and total project costs.
Clearing & Grubbing	• Clear only as much area as needed over the short term. • Clearing can start up to two years in advance. • Erosion control should be installed before clearing starts. • Byproduct & Waste Management Module provides advice on handling and storage of grubbed material.
Topsoil & Overburden removal	• The Stockpiling Module provides advice on topsoil storage. • Progressive mining allows for "Live Topsoiling."
Berms (landscape)	• Coordinate extraction (stripping) with berm construction.
Drilling & Blasting	• Refer to qualified professionals. • Note *Mines Act*, Health & Safety & Reclamation Code.
Location & Orientation of Working Face	• Strategic placement and orientation of the working face can significantly reduce visual, dust and noise impacts.
Loading and Hauling	• Match loading and hauling equipment to each other, the deposit characteristics and processing equipment. • Minimize or avoid double handling.
Equipment Selection	• Equipment selection can make a difference in extraction efficiency and noise and dust reductions.
Haul Roads	• Haul roads should be short, straight, with minimal hills and have sufficient stopping distances and good vision. • Keep roads both dry and dust free.
Primary/Secondary Processing Locations	• Processing can be continuous or intermittent. • Location of the processing plant or facility can significantly reduce visual, dust and noise impacts.
Water Management	• Coordinate extraction with location of settling ponds.
Stockpiling	• Coordinate extraction with stockpiling.

Table EM - 2: Non-production related extraction planning considerations.

Non-production Considerations of Extraction Planning	
Noise	• Locate and orient the working face to intercept and reflect noise away from sensitive areas. • Locate loading and unloading facilities in an area where noise will be absorbed and not broadcast (i.e., not on an exposed hillside). • Generators can be particularly noisy. Locate them in an area that will dampen their noise.
Visual Concerns	• Locate and orient the extraction working face and haul roads so that they are concealed from neighbours and roadways.
Dust	• Locate and orient the extraction working face and haul roads so that they are not in wind "chutes" or susceptible to strong winds.
Traffic	• Locate the extraction working face and haul roads so that they are concealed from neighbours and roadways and protected from strong winds.
Pollution Prevention	• Locate spill kits close to the working face and on equipment to handle upsets and spills. • Ensure good maintenance. • Ensure proper training plan in place. • Utilize blasting practices that minimize release of nitrogen compounds.
Erosion, Sediment and Stormwater	• Keep the extraction area and hauls roads free of ponding water from rainfall and upslope sources.
Environmental	• Consider/address special on-site or adjacent environmental features within the extraction plan.
Reclamation	• Coordinate extraction with reclamation plans. • Plan extraction to minimize reclamation work.

Extraction Planning: Key Pointers

Using Maps to Detail Extraction Plans

Maps are the best tool to show the location of the extraction face, how extraction will proceed and, if possible, phases of progressive reclamation.

Chapter 4 of this handbook, Mine Planning, has detailed advice on how to prepare maps for aggregate operations. That chapter refers to the maps (schedules) that should be included with a Notice of Work & Reclamation for a Gravel Pit or Quarry application. An "extraction plan map" is also commonly referred to by the name "mine development map."

Matching Extraction Planning to Proven Reserves and Proposed Product

Before selecting equipment to work the face and move the material, an operator should know the grade, competency and quantity of the sand and gravel, or the hardness, lithology and rock structure of the quarry material and, in either case, potential production rates and volumes.

Sand and gravel deposits can be assessed using back hoe or excavator test pits, test holes drilled with a continuous flight auger or land form analysis (e.g., river terrace, delta, alluvial fan). For quarries, geological mapping, rock sampling and drilling can prove the extent of the extractable material. Operators should avoid areas with the potential for acid rock drainage, as discussed in Chapter 2.

The proposed mining sequence and pit or quarry shape will be largely determined by both the deposit characteristics and the lay of the land. For uniform deposits on flat land, a wide range of extraction sequences could be used to maximize operational and non-technical goals. In tight situations where the deposit is deep and the quality of the aggregate varies considerably, options for extraction sequences and pit configurations may be severely limited.

Start-up Space Problem

A sand and gravel pit or rock quarry requires a lot of space. Start-up can be one of the most difficult stages of an aggregate operation. During start-up, an operator must determine how much area should be cleared and grubbed, where top soil and overburden piles should be placed, where the extraction face should start, whether there is enough room for processing and when product can start to move, all in the shortest possible time frame. Other modules, such as stockpiling and processing, will help to solve these problems.

Without proper planning, the temptation to simply place the overburden pile somewhere convenient "until we get going" may be irresistible, but the time required for moving the pile a second time ("double handling") will far outweigh the time saved initially. Adequate up-front extraction planning will help an operation start up more smoothly and quickly, while minimizing double handling of materials once the operation is running in full swing.

Visibility

Where to begin the extraction face in order to minimize off-site impacts is an important decision. Commonly, an operator will start near the access point and work towards the back of the property.

This approach puts all activities where they are most visible right away, at a sensitive time for developing community relations.

A number of operations have found that starting extraction in a less visible part of the property, and away from neighbours, allows the property itself to act as a buffer. In this way, mitigation tools such as treed berms will have been established to control dust and noise and act as visual screens before the operation approaches neighbouring properties. Also, a less visible operation is far more conducive to establishing good community relations at an early stage.

Working Top Down

The conventional place to begin excavating a hillside gravel deposit is at the bottom of the slope. Consequently, the entire hillside may have to be exposed prior to reclamation and slopes may be cut too steeply, making them more prone to failure. Consider establishing the first excavation face at the top of a hillside and working down in benches or lifts. Reclamation can proceed on each bench as the next is opened up. In this way, the potential for slope failure is minimized

Starting at the top also allows for more control of the orientation of the face. A properly orientated face may be less visible from local residences and highways, act as a barrier for noise and reduce wind exposure and dust generation.

Straight Short Haul-Roads

The path between the working face and a primary processor (crusher) should be as short and straight as possible. Corners and hills require haul trucks to slow down, decreasing their operating efficiencies. If bends are required in the processing stream, then they should be at processing points. Grades should generally not exceed 10%, and road corridors should conform to the Health, Safety and Reclamation Code Section 6-8 specifications.

Both access and haul roads are further discussed in the Traffic Module and the Haul Roads BMP.

Keeping It Dry

Designing the extraction process to remain dry will benefit an operation in three ways. First, wet material is more difficult to process and requires drying once processed. Attempt to keep material dry until washing is required.

Secondly, wet working areas increase wear and tear on tires and equipment. Wet tires are five times as susceptible as dry tires to slashing from sharp objects like rocks. Some wetting may be required for dust control.

Thirdly, water collected from the excavation area requires treatment in settling ponds to remove sediment. Settling ponds require valuable space. If there is a risk of an oil or hydraulic fluid upset, runoff water may have to be treated in an oil/water separator.

The extraction area can be kept dry by using diversion ditches, back-draining benches, and well-drained, crowned and elevated haul roads.

Clearing & Grubbing

Clearing is the removal of trees and vegetation and grubbing is the removal of stumps and root systems. Local bylaws may regulate these activities. To cut down on dust, visibility and stormwater impacts, clearing and grubbing should be restricted to the areas that will be actively used for extraction, processing and stockpiling in the near future. If possible, these areas should be cleared and grubbed immediately prior to extraction.

The Ministry of Forests (MOF) has a mandate to regulate timber harvesting on Crown land. Thus, the MOF should be notified well in advance of tree removal, so that any possible resource conflicts can be settled and an appropriate Licence to Cut or Free Use Permit obtained, in accordance with the *Forest Act*.

Stumps and roots are normally burned or buried, subject to the *Waste Management Act* regulations. While chipping stumps is sometimes an option, it is generally prohibited by regulation because recent research has shown that stockpiled chips can leach acids. An alternative is to stockpile the stumps into berms or "beehives". The stumps can be later spread over the site during reclamation, if forestry is planned, or used for erosion control. Stumps can provide habitat for birds, small animals and insects, and may enrich the soil when decayed (Buchanan, 1999).

Blasting

Blasting can integrate extraction with processing by fragmenting rock into an optimal size for feed into the processing stream or for direct sale. In a blasting program, it is important to consider the structural discontinuities of the rock mass and the rock material strength.

While blasting expertise will not be discussed in this handbook, the Health, Safety and Reclamation Code for Mines in British Columbia has very specific requirements regarding explosives. *Mines Act* certification is required for all blasters at pits and quarries. Fisheries and Oceans Canada has published guidelines for the use of explosives in or near Canadian fisheries waters (Wright and Hopky, 1998). Suppliers of explosives can provide technical advice and valuable information.

Extract to Reclamation

Well-planned extraction can give reclamation a head start by reducing the amount of post-extraction work to be done. Final slope angles, shapes and grades can be established during extraction rather than as a separate operation (Norman et al., 1997), even if progressive reclamation is not an option.

Where the shape of the deposit and lay of the land allow for phased extraction, progressive or segmented reclamation may be an option. Progressive reclamation can reduce topsoil and overburden handling, reduce the need for large stormwater management areas, prevent dust generation, reduce the amount of reclamation security required as a permit condition, and allow post-mining land uses to begin earlier.

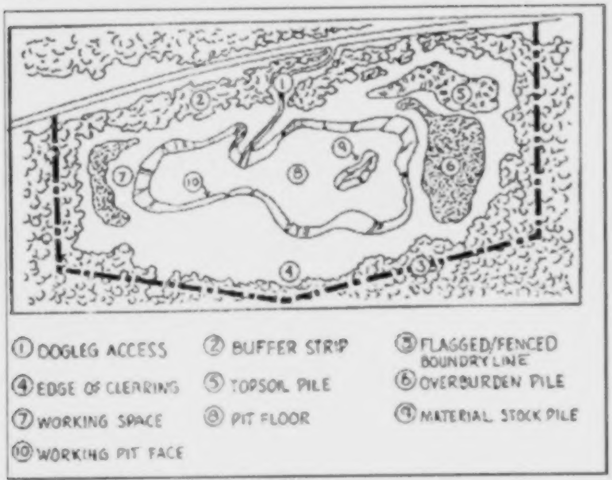
Benching

Benches are required where the working face in unconsolidated material would exceed the reach of loading equipment (refer to the Health, Safety and Reclamation Code Section 6.7.7). Benches are stable, can control stormwater runoff and are easily reclaimed. Back-sloping and crowning benches stop water from running over the face of the bench, and prevents sheet, rill and gully erosion and the entrainment of sediment into storm water. Benches should be maintained at a minimum width of 8 metres.

Table EM - 3: Extraction activities and related modules and BMPs.

Extraction Activities	Modules	Applicable BMPs
Clearing & Grubbing	SITE LAYOUT • Noise Section • Dust Section	• Berm • Silt Fence
Topsoil & Overburden	STOCKPILING	• Topsoil Management
Location & Orientation of Working Face	SITE LAYOUT • Visual Landscape Section • Noise Section	• Sinking the Plant
Haul Roads	TRAFFIC SITE LAYOUT • Visual Landscape Section • Noise Section • Dust Section	• Haul Road
Loading & Hauling	SITE LAYOUT • Noise Section • Dust Section	• Drop Height • Dust Skirt • Water Spray
Equipment Selection	SITE LAYOUT • Noise Section	• Equipment Selection
Primary/Secondary Processing Locations	PROCESSING	• Sinking the Plant
Washing	PROCESSING	• Settling Pond
Water Management	STORMWATER & EROSION CONTROL	• Ditches • Retention Basin • Silt Fence
Stockpiling	STOCKPILING	• Berm • Material Corrals • Tarps
Reclamation	EXTRACTION SITE LAYOUT	• Backfilling • Tillage

Figure EM - 4: Sample extraction map.


① DOGLEG ACCESS
② BUFFER STRIP
③ FLAGGED/FENCED BOUNDRY LINE
④ EDGE OF CLEARING
⑤ TOPSOIL PILE
⑥ OVERBURDEN PILE
⑦ WORKING SPACE
⑧ PIT FLOOR
⑨ MATERIAL STOCK PILE
⑩ WORKING PIT FACE

Source Indian and Northern Affairs Canada, 2001.

5 - 2 PROCESSING MODULE - PM

Common Concerns: Aggregate Processing

The processing plant at an aggregate operation may include crushers, screens, wash plants, generators and conveyors, and is often the focal point for heavy equipment activity at the site. As a result, aggregate processing may cause concerns relating to noise, dust and visual impacts. This module will discuss how and where to set up processing facilities to minimize land disturbance and community and environmental concerns.

Process planning can identify changing plant needs, in order to coordinate improvements with the development of other site activities over the life of a mine. To identify these needs, processing planning should consider:

- extraction planning,
- stockpiling planning,
- stormwater & erosion control planning, and
- traffic planning.

Addressing Processing Plant Concerns

Processing of aggregate material can use a lot of water and energy, and may create undesirable noise, dust and visual impacts, and by-products such as sediment-laden water and wash-water fines. Reducing or mitigating processing plant concerns can start with the design of the processing plant and with equipment selection and layout. Table PM-3 lists various types of processing equipment, potential concerns associated with them, notes, pointers, and BMPs that can be used to address concerns. Table PM-4 lists some potential concerns and offers suggestions and BMP selections for mitigation.

Safety is an important factor in plant design. Individual equipment should have adequate guarding, conveyor rules should be established and followed, and operating protocols should be clearly established. Refer to the Health, Safety and Reclamation Code Section 6-8 for plant safety regulations.

Processing Plant Location

The location of the processing plant should allow for the coordination of extraction, stockpiling, load-out facilities, available space and other strategies to contain noise, dust and visual impacts. As Tables PM-3 and PM-4 indicate, strategic location is a primary tool for mitigating processing plants, and sometimes-different factors must be balanced. For example, a high plant location will facilitate the directing and treating of stormwater, whereas low locations are advantageous when noise or dust may be a significant issue. Extraction planning will help determine if and where there will be in-pit crushing or whether a fixed primary crushing station will be used.

Plant Type

Before starting to purchase equipment, an operator should determine what type of processing plant would provide the best balance between optimizing production and potential noise, dust and visual concerns. The basic types of plants are listed Table PM - 1.

Table PM - 1: Basic types of processing plants.

	Processing Plant Type	Description
1	**Stationary Plant**	• buildings and infrastructures with concrete foundations • long-term and large operation • large space requirements
2	**Semi-fixed Plant**	• less than 10 year life expectancy • skid-mounted equipment and mobile conveyor systems
3	**Mobile Plant**	• used at different locations for in-pit processing during separate phases of the mine extraction plan • can also be used for smaller operations • equipment is rubber-tired or skid mounted
4	**Seasonal / Contract Plant**	• contract processing facility • seasonal or intermittent • rubber tired or skid mounted equipment

After: Pit & Quarry Quarryology 101, Lesson 3 Plant Design / Components, Part 1, "Type of Plant".

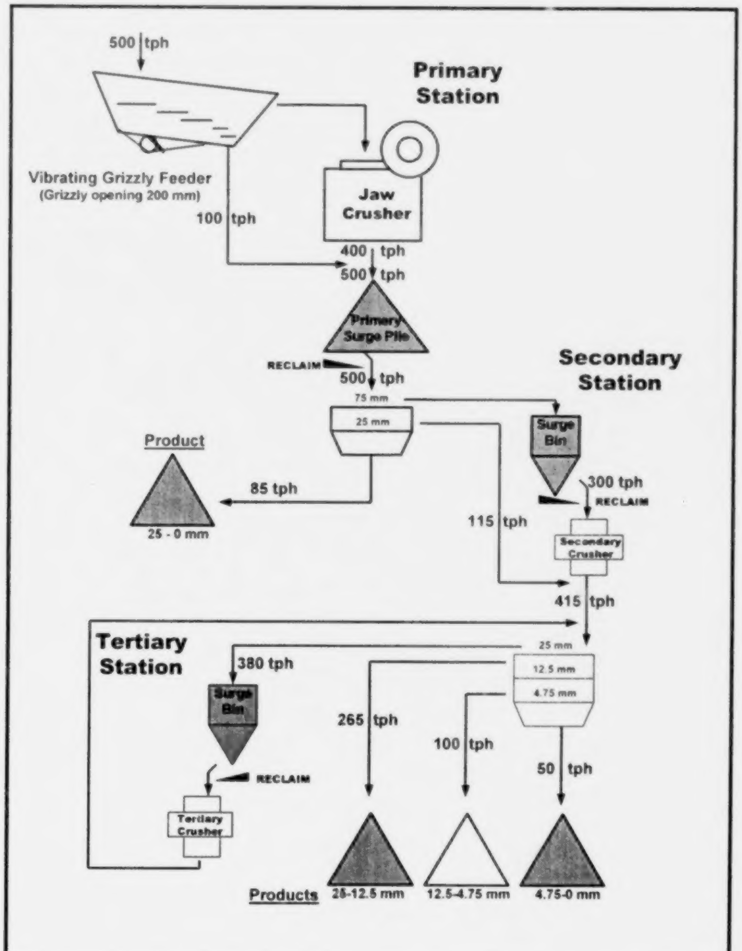
The Processing Plant Flow Sheet

The selection of specific equipment with individual production capacities should be based on the type and estimated volume of processing proposed for the operation. This selection can be assisted using a *Processing Plant Flow Sheet,* as illustrated in Figure PM - 2. The *Flow Sheet* illustrates the "planned" configuration of machines, conveyors and chutes, and shows estimates of the tonnes-per-hour flow of each component. When putting together a *Processing Plant Flow Sheet*, an operator can begin to solve some of the following problems:

- What is the best plant type? (stationary, semi-fixed, mobile, or seasonal)
- What are the crusher requirements? (crusher required? contract required? size, type, power requirements, etc.)
- Should wet or dry processing be used?
- What types of screening will be required? (fractionation needs, screen types, volume, numbers of screens, sizes, etc.)
- Will sand screws be used?
- What are the washing requirements?
- How will surge piles be used? (where, how deposited, how big, reclaim equipment,etc.)

The *Processing Plant Flow Sheet* attempts to predict processing plant performance given the variability of the raw material feed, rates of feed and desired production and output rates. It can also help to predict the space requirements for equipment, stockpiles, support facilities and access. Pointers for equipment selection and planning notes are given in table PM-3 for many of the typical equipment types and components in an aggregate processing plant.

Figure PM - 2: Example of a *Processing Plant Flow Sheet* for a 500 ton per hour (tph) plant.


500 tph
Primary Station
Vibrating Grizzly Feeder
(Grizzly opening 200 mm)
100 tph
Jaw Crusher
400 tph
500 tph
Primary Surge Pile
RECLAIM
500 tph
75 mm
25 mm
Secondary Station
Surge Bin
Product
85 tph
25 - 0 mm
300 tph
RECLAIM
115 tph
Secondary Crusher
415 tph
Tertiary Station
25 mm
380 tph
12.5 mm
4.75 mm
Surge Bin
265 tph
100 tph
50 tph
RECLAIM
Tertiary Crusher
Products
25-12.5 mm
12.5-4.75 mm
4.75-0 mm

After: Bowers et al. 1990, figure 8.18, page 8-70.

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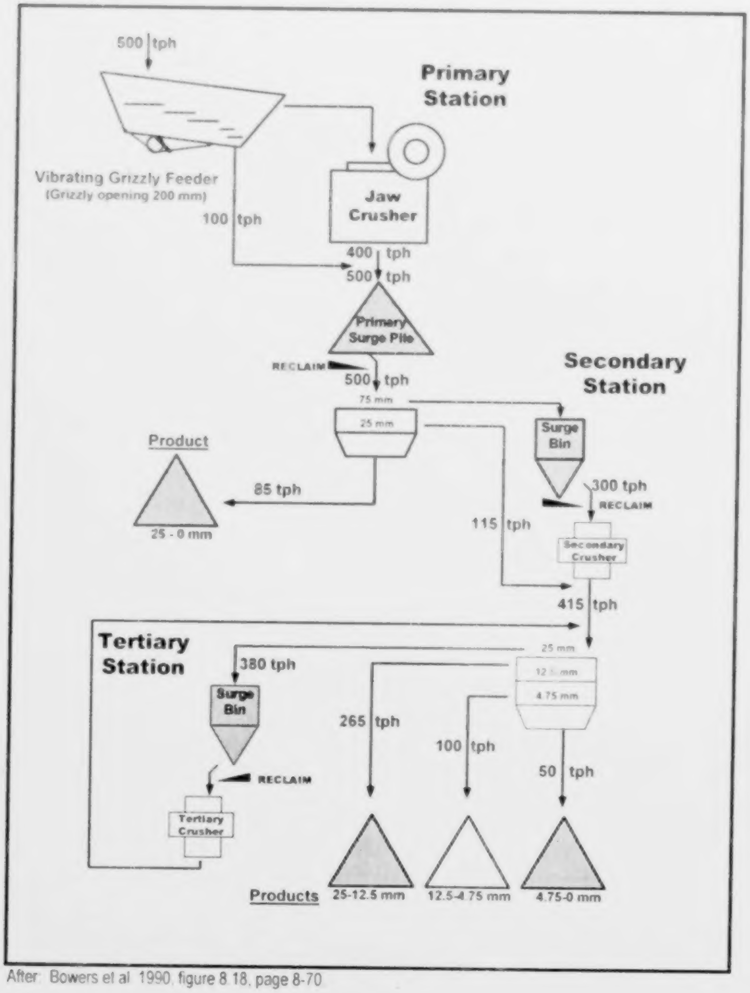

500 tph
Primary Station
Vibrating Grizzly Feeder
(Grizzly opening 200 mm)
100 tph
Jaw Crusher
400 tph
500 tph
Primary Surge Pile
RECLAIM
500 tph
75 mm
25 mm
Secondary Station
Product
Surge Bin
85 tph
300 tph
RECLAIM
25 - 0 mm
115 tph
Secondary Crusher
415 tph
Tertiary Station
380 tph
25 mm
12.5 mm
4.75 mm
Surge Bin
265 tph
100 tph
50 tph
RECLAIM
Tertiary Crusher
Products
25-12.5 mm
12.5-4.75 mm
4.75-0 mm

After: Bowers et al. 1990, figure 8.18, page 8-70

Table PM - 3: Typical processing plant equipment and components and related potential noise, dust and visual issues.

Component	Description	Issue	Process Flow Sheet Pointers	Planning Notes	BMPs
Crusher	• reduces the size of material	• noise • dust from feed and discharge	• make large size (> 4 : 1) reductions in stages • primary crushers are usually jaw crushers	• noise travels in uninterrupted lines of sight, and can reflect off barriers and buildings • place crusher in hollow or low on the property • use working face as noise barrier for primary crusher • enclose or surround crushers with berms, walls or other sound barriers • surround with or locate near thick vegetation • water spray into the crusher feed can effectively reduce dust	• Berm • Drop Height • Dust Skirts • Equipment Selection • Fences • Lighting Management • Sinking the Plant • Water Spray
Screens	• separate aggregates into various sizes	• noise • dust from feed and discharge • wet screenings produces silt laden water	• dry screening reduces product drying and water processing requirements, yet may require dust suppression	• polyurethane and rubber screens are quieter than wire cloth screens	
Conveyors	• transport aggregate on powered belts	• dust from feed and discharge • visual	• variable height conveyors can limit stockpile segregation and dust	• dampen material to reduce dust at transfer points • variable height conveyors may reduce dust generation and visual impacts	
Chutes	• direct falling aggregate into a feeder	• dust from feed and discharge	• gravity feed is controlled by material size and moisture content		
Grizzly	• static rejection of oversize • removes fines to bypass primary crusher	• dust • noise	• commonly overloaded and inefficient		
Surge Pile	• isolates components of processing plant, smoothing out erratic production rates	• dust • noise • appearance	• should be large enough to ensure no one piece of equipment overwhelms / undersupplies the next station • large piles allow for operational flexibility, but are segregation-prone and require more space	• sprinklers should not be used on surge piles with automated recovery tunnels, as high moisture content may limit flow rates and processing efficiency (not an issue for front-end loader recovery)	• Drop Height • Dust Skirts • Signage
Transfer Points	• where a stream of aggregate, such as on a conveyor, makes an abrupt change in direction or elevation	• dust		• hoods control exposure to wind and reduce dust	• Drop Height • Fences • Water Spray
Washing / Rinsing	• rinsing material to remove fine particles to meet product specifications	• silt-laden water	• budget for 10 - 40 litres per tph • use proper high pressure nozzles • keep material in thin layer to wash • prior to washing, remove as many (dry) fines as possible • pre-wet material		• Lighting Management • Settling Pond

Table PM - 4: Concerns, requirements and by-products of aggregate processing plants.

Factor	Related Plan	Issue	Mitigation	BMPs
Water Supply		• washing / rinsing can use 10 - 40 litres per tph, of which a significant portion is lost in processing	Makeup Water Options: • captured storm water • water well • municipal water • water licence from local stream or lake	
Energy		• energy can be a major component of the cost per tonne of product • mobile electric generating plants may be noisy and dusty	• purchase energy from a grid • use enclosed plants with appropriate mufflers	
Noise	**Noise Plan**	noise may be generated by: • power plants • rock impacting metal • equipment noise (crushers) • loaders used to supply the plant • load out facilities & trucks	• use rock on rock transfer points • use rubber or polyurethane products for screens, chutes and truck liners • use low profile processing systems so noise is absorbed or blocked by the landscape • use non-audible back-up alarms (HSRC Section 12.31)	• Berm • Buffer Zone • Fences • Sinking the Plant
Dust	**Dust Plan**	potential sources of dust include: • roads • feeds and discharges for conveyors, crushers, screens • front end loaders moving material, • loadout facilities	• water roads or use surfactants (calcium chloride) • wheel washer • wash down trucks • pave high use areas • install bag house • water sprays • wind breaks	• Buffer Zone • Drop Height • Dust Skirts • Water Spray
Visual	**Visual Landscape Plan**	• processing facilities may be less attractive than overall surroundings	• low profile processing systems • use downcast lighting • berms for screening • vegetation cover to blend in with native vegetation • select a location which is hidden by local topography	• Berm • Buffer Zone • Fences • Lighting Management
Water Treatment	**Processing Plan**	• process water is heavily silt-laden, • in very high rainfall locations, periodic discharge may be necessary	• closed circuit settling ponds for decanting (requiring substantial land base, with periodic clean outs) • containment cells • clarifiers • approved flocculants • dilute occasional discharge with stormwater	• Settling Pond
Silt	**By-product and Recycling Plan**	• recovery and disposal of fines from settling pond, retention basin and other sediment traps such as check dams	• remineralization as an agricultural supplement	
Stormwater	**Stormwater Plan**	• stormwater may cause erosion and deposition of fine sediment in local waterways	• place processing plant in a locally high and dry location • wash down equipment to prevent rain water siltation off equipment surfaces	• Ditches • Retention Basin

5 - 3 STOCKPILING MODULE - SM

Common Concerns: Stockpiling

Stockpiles take up a lot of land. At small operations, the stockpile might represent half of the total land base. In tight urban areas, stockpiles may be the most significant visual feature of an aggregate operation and their placement or concealment requires careful consideration. Because of their large footprint, stockpile sites can also generate a large portion of an operation's stormwater, requiring appropriate management attention.

Handling and storage are major cost elements of both extraction and processing. Accordingly, there should be a plan for each aggregate operation showing how and where materials and products will be handled and stored.

Image SM - 1: Stockpiles of aggregate.

Photo courtesy of Devon County Minerals Local Plan, UK.

A stockpiling plan will help to ensure quality control by keeping finished product from becoming unintentionally blended, segregated or contaminated. When stockpiles are well placed between extraction, processing and loading facilities, hauling distances are minimized, saving time, fuel and machinery maintenance. Stockpiling planning will also organize placement of overburden, topsoil and by-products, helping to avoid double handling of low-value materials.

Basic Stockpiling: What and Where?

Stockpiles can be constructed using front-end loaders, trucks or conveyor systems. The types of stockpiles and stockpiling procedures will depend upon the available land and equipment, the flow characteristics of the material, the climate and length of the processing season, quantity of material and range of products.

Table SM-2 compares various commonly stockpiled materials for storage and handling options.

Table SM - 2: Aggregate products and storage options.

Material	Flow Constraints			Handling Equipment		Bulk Storage and Stockpiling Options				
	Flow Char.	Fines	Moisture	Front-end Loader	Conveyor	Cone	Layered	Corral	Bin	Berm
Pitrun	fair	high	mod	✓	✓	✓	✓			
Topsoil	poor	high	mod	✓		✓	✓			✓
Overburden	poor	high	high	✓		✓	✓			✓
Clay	poor	high	high	✓	✓	✓	✓			✓
Gravel	good	low	low	✓	✓	✓	✓	✓	✓	
Sand	good	mod	high	✓	✓	✓	✓	✓	✓	
Sand and gravel	poor	mod	mod	✓	✓	✓	✓	✓		
Coarse rock	mod	low	low	✓		✓	✓			
Crushed aggregate	good	mod	low	✓	✓	✓		✓	✓	
Washed aggregate	good	low	mod	✓	✓	✓		✓	✓	
Blended aggregate	good	low	mod	✓	✓	✓		✓	✓	
Riprap	poor	none	low	✓		✓	✓			
Reject material pile	poor	mixed	low	✓		✓	✓			✓
Woody debris	poor	high	high	✓		✓	✓			

General Stockpiling Guidelines

- Sites for stockpiles should be clean and level prior to storing materials.
- Aggregates should not be removed from stockpiles within 0.3 metre (1 foot) of the ground until final cleanup/removal of the stockpile.
- Layering can help to minimize moisture absorption in stockpiles. Tarps can also be used for products that need to be kept dry.
- Stockpiles can be located to function as sight and sound barriers.

Table SM-3 outlines the major considerations, options and applicable BMPs for stockpiles.

Table SM - 3: Stockpiling issues, significance, notes and suggested BMPs.

Issue	Significance	Notes	Suggested BMPs
Segregation - the unintentional and undesirable separation of aggregate into size fractions	• depends upon type and height of stockpile, drop height, handling equipment and procedures	• segregation can be triggered by any movement and/or vibration • avoid end-dumping or dozing over the sides of piles • fix improperly placed or malfunctioning conveyors • segregated material can be re-blended by dozing stockpiles and dead surge areas • frozen crust can increase segregation and decrease product quality	• Drop Height
Degradation - the breaking of aggregate pieces into smaller size fractions	• occurs if the aggregate is falling far enough to break on impact or if machinery is driven on top of it	• avoid excessive machine time on top of aggregate	• Drop Height

Location/Space	• depends upon available land	• keep stockpile sizes to a minimum, as the material in stockpiles represents an investment in inventory
		• provide room for loaders and trucks to manoeuvre
		• locate to reduce noise escaping the site
		• consider prevailing wind patterns
		• allow sufficient distance from fences and property boundaries to prevent overflow or spillage
		• avoid proximity to utilities, whose underground structures may be damaged by ground deflection from the weight of the stockpiles
		• avoid locating stockpiles under overhead wires where equipment may contact the wires
		• provide sufficient area for both stockpiles and operations, such as:
		  • subsequent crushing and processing
		  • Sub-contracting
		  • mixing plant
		  • weigh scales
		  • parking and mobile buildings
			• Material Corrals

Drainage	• wet handling areas due to collected rainwater increase costs	• use high, dry and well drained ground • avoid ponding • stockpiles may compact the ground, decreasing local infiltration rates • compact material with high fines to reduce water absorption	• Ditches • SEC Module • Settling Pond
Safety	• depends upon size and whether automatic reclaim systems are installed • frozen ground can also be dangerous	• avoid creating hazardous slopes, or stabilize • prevent inadvertent and unauthorized access • keep stockpile back from perimeter and fences to avoid entry breaches • prevent access to top of stockpile (i.e. remove access ramp) • falling frozen chunks/crusts can be very dangerous	• Fences • Signage
Accessibility/ Orientation	• depends upon traffic flow from and to stockpiling area	• provide for year round accessibility • for multiple vehicle access types (e.g., haul trucks and highway trucks), consider separate access roads to avoid traffic conflicts • design for safe, orderly and efficient access • ensure optimum utilization of space for efficient existing or anticipated removal and processing operations • provide for adequate separation from the various operations • limit height to avoid loading out faces from becoming too high	
Ground Stability	• generally only a concern in low, wet areas • frozen ground can also be unstable	• stockpile areas should be on stable ground during all weather conditions • stockpiles should not be adjacent to unstable ground, either up or down slope	
Proximal Activities	• depends upon proximity to non-industrial neighbours	• avoid locating stockpiling areas adjacent to public or residential areas • stockpiles can be a major source of dust • place stockpiles so that the prevailing wind will not create adverse dust effects on sensitive areas • consider placing buffers on the downwind side of stockpiles • can be used for noise and visual screens from other activities on site	• Water Spray

5 - 4 TRAFFIC MODULE - TM

Common Concerns: Aggregate Truck Traffic

Transport can be the single largest cost factor per tonne for aggregates, for both on-site hauling and off-site delivery. Haul truck operations, safety and efficiency are crucial in keeping costs per tonne down.

Residents and local governments commonly cite off-site traffic as a major concern regarding aggregate operations. Dump trucks can be noisy and dirty and their size can be intimidating. Their slow acceleration may add to congestion and, with frequent use, their weight can cause road deterioration. Unless an operation has its own fleet of trucks to deliver aggregate to off-site customers, individual truck issues are the responsibility of the trucking companies and managing local traffic is the responsibility of the local community. Nonetheless, producers can develop company traffic protocols to help manage these issues and work in conjunction with trucking companies and local governments. While on-site and off-site traffic planning can be combined in some situations (e.g., where highway trucks are loaded at the working face to transport material directly off-site), for many larger operations the issues are sufficiently distinct that planning for them can be done separately.

On-site traffic planning considers aspects of haul roads and industrial traffic, site entrance and exit design, weigh scale layout, and can help alleviate noise, dust and visual impact. On-site traffic is regulated by the Health, Safety and Reclamation Code for Mines in British Columbia. An on-site traffic plan may be a condition of the *Mines Act* permit. Operators are advised to consult with their local inspector of mines on the application of Code requirements for their individual operations. Where trucks access a provincial highway directly from an operation, a highway access permit may be required.

Off-site traffic planning can scope out concerns and suggest measures to limit impacts. Local planners will often request estimates of volumes, times and destinations of truck traffic, but traffic is often unpredictable due to seasonal variations and market demands. Traffic planning can also recommend driver protocols and can highlight measures the aggregate producer can take to reduce the impact of off-site traffic.

On-Site Traffic

Noise, Dust and Visual Impact Considerations of On-Site Traffic

On-site traffic may generate dust and noise and may detract from the landscape character of an operation. The dust, noise and visual landscape sections in the Site Layout Module in this handbook all make recommendations with respect to on-site traffic. Table TM-1 summarizes the BMPs for consideration for on-site traffic management planning.

Table TM - 1: On-site traffic BMPs to reduce dust, noise and visual impacts

BMPs* & Other Measures	Description	Dust	Noise	Visual
Speed Controls	reducing truck speeds from unregulated to: • 50kph can reduce dust by 25% • 30kph can reduce dust by 65% • 25kph can reduce dust by 80%	✓		
Sheet Vehicles	• covering loads with tarps or sheets	✓		
Road Surfacing*	• topping or paving high volume on-site roads with dust free material to reduce dust generation and create a smoother, quieter running surface. Dust generation from traffic may account for up to 40% of all dust generated at a gravel pit or quarry.	✓	✓	
	• paving roads between washing facilities and site exits	✓	✓	✓
Sweeping	• sweeping surfaced roads to reduce dust	✓		
Drop Height	• reducing drop height into trucks can reduce dust generation by up to 25% for that activity, and reduce noise and energy cost to lift material	✓	✓	
Spray Facilities	• spraying loads in unsheeted trucks with water or stabilizer can reduce dust	✓		
Wheel Washer	• installing a wheel washer will prevent mud from leaving the site, reduce dust and make the overall site and adjacent roads cleaner.	✓		✓
Road Sprays*	• regularly spraying roads with water or dust retardant can reduce road dust by as much as 50%	✓		
Site Layout	• locating roads at the lowest possible elevation on site reduces noise transmission, dust dispersal and visual intrusion	✓	✓	✓
	• not placing road along a ridge, or allowing it to cross ridges, as that would create a conspicuous break in the skyline	✓		✓
	• keeping roads off of ridges also reduces the visibility and spread of dust			
	• using the lay of the land to hide roads, reduce exposure to wind and to muffle noise	✓	✓	✓
	• locating roads down wind from sensitive neighbours reduces dust and noise migration towards those neighbours	✓	✓	
Refuse to Overload	• overloading trucks can cause material loss on-site and off-site, which eventually becomes fugitive dust	✓		
Road Maintenance	• grading and compacting road surfaces to prevent uneven running surfaces, which create both noise and dust	✓	✓	
Upswept Exhaust	• using upswept exhausts to avoid dust generation	✓		
Dust Skirt Loaders	• applying dust skirts on overhead bin or conveyor loadout facilities for trucks can reduce dust by 75% during the loading process	✓		
Protect / Screen Roads	• placing berms, trees, shrubs, or fences upwind of haul roads to reduce wind exposure and interrupt noise and sight lines	✓	✓	✓
Strobe Back-up Alarms	• using strobe lights as an alternative to back up alarms. Request for a variance from the Code requirement for audible alarms should be sent to the Chief Inspector of Mines, cc'd to the Regional Mines Branch inspector		✓	
Radios*	• using radio communications instead of horn signals		✓	
Maintenance	• tightening loose and rattling hitches, etc.		✓	
Non-engine Brakes*	• avoiding use of engine retarder brakes within urban areas		✓	
Entrance Layout*	• staggering, off-setting or curving the site access to prevent direct views into the site			✓
Loading Facilities*	• locating loading facilities to shield visibility from off site locations			✓

* Some BMPs may not be included in this handbook.

Managing On-Site Aggregate Traffic

Managing on-site traffic largely involves initial organization of protocols and procedures. Initial set-up time and costs will likely be recouped through prevention of lost time and resources needed to deal with traffic concerns. An effective tool for managing on-site traffic is an on-site traffic map, which could be part of or based upon an extraction or mine development map.

Considerations for On-Site Traffic Planning:

- location of mine roads
- types and volumes of traffic (including personal transport) likely to use on-site roads
- speed limits
- noise, dust and visual impacts that may affect proximal features and facilities (e.g. residences, schools, retirement homes, hospitals)
- entrance and exit requirements, and whether access is to a highway under The *Highway Act* or to a local road
- a right-of-way hierarchy
- entrance/exit, loading facilities and mine-road layout to avoid unnecessary noise, dust and detracting views
- traffic and personnel transport protocols and procedures
- an on-site traffic map
- runaway lanes or retardation barriers on steep grades
- posting maps, routes, protocols and procedures at the entrance, office, garage, parking lot, etc.
- training on-site workers and preparing an "on-site traffic expectation handout" for contractors entering site.

Off-Site Traffic

Off-site traffic is a commonly cited concern about aggregate operations, both by residents and local governments. Table TM-2 identifies and discusses a number of these traffic concerns and suggests BMPs and other mitigation measures.

Table TM - 2: Off-site aggregate traffic concerns and mitigating BMPs and other measures

Local Traffic Concern	Description	BMPs & Other Measures
Noise	• the large engines used to power dump trucks, and their heavy-duty braking systems, are substantially louder than domestic motor vehicles, often drawing negative attention to the trucks	• Equipment Selection • driver training
Driver Behaviour	• the heavy loading, high noise levels and large size of dump trucks accentuate their movements, and may create the impression of aggressive driving • the nature of product delivery businesses, where time is money, may encourage aggressive driving behaviour	• driver training
Truck Visibility	• industrial vehicles and dump trucks are big and noticable, heightening perceptions regarding aggregate supply and delivery traffic	• Signage • turning lights
Vibration	• heavy vehicles, especially during hard braking, can cause ground vibrations which may be felt up to 250 metres away, depending upon local soil conditions and the sensitivity of local buildings (e.g., rattling china cabinets)	• driver training
Traffic Volume	• on low-volume roads, dump trucks from local aggregate operations may significantly increase local traffic • on already over-subscribed, high-volume roads, added truck traffic will aggravate existing problems • large trucks are readily noticed, and it may seem like there are more of them than there actually are	• trip timing
Dust	dust can be generated by: • *blow-off* from inside the box • *bounce-out* from rough roads or fast braking • *fall-off* from exterior box ledges from sloppy loading • *mud-fall* off from the underside of a truck onto the road	• Wheel Washer • avoiding overload • loading chutes • truck sheeting • wash trucks
Visual Impacts	• large high-sided trucks can cause obstruction or block views • away from construction sites, dump trucks can seem out of place and intrude upon a setting such as a residential area	• Berm • Fencing • hedges
Landscape Character	• large trucks can mar the perception of tranquillity and wildness	• Berm • hedges
Detachment	• residents, pedestrians, and other road users can feel separated and cut off because of the perceived difficulty of crossing a road heavily traveled by large trucks	• crossing lights • pedestrian bridges
Fear and Intimidation	• the volume, size of trucks, speed of traffic and proximity to people increases the likelihood of pedestrian and cyclist fear and intimidation • this factor is also influenced by road width, curb presence and shoulder size	• Fencing • road widths • speed reductions • shoulders • sidewalks
Highway Safety	• increases in traffic volume result in increased road safety hazards for all road users, pedestrians and residents	• Fencing • speed reductions
Road Degradation	• heavy-load traffic can damage roads, depending upon the age and grade of the pavement and construction standards	• avoiding overload • road standards • road upgrades

Managing Off-Site Aggregate Traffic

Some of the BMPs and other measures suggested in Table TM - 2 can be taken by the producer, some by the trucking companies and their drivers, and some by the road and highway authorities. Table TM - 3 lists these actions in association with the organizations or persons that would normally undertake them. Working with the local planning authorities in advance of production will make managing specific aggregate traffic easier.

Table TM - 3: Suggested off-site truck traffic actions, by applicable organization

Producer	Trucking Company / Truck Driver	Road Authority
• Receiving, recording and acting on complaints • Avoiding overload • Spraying or covering outgoing loads • Refusing to load rogue drivers • Washing wheels • Loading with chutes to avoid spillage	• Sheeting trucks • Reducing speed • Driver training • Trip timing to avoid rush hours • Equipment selection • Washing trucks • Painting trucks with visually appealing images or colours	• Trimming roadside vegetation for visibility • Crossing lights • Signage • Signal lights • Insulating roads with acoustic fences, berms or shrubs. • Curbs • Planning for wide roads with adequate shoulders • Sidewalks • Pedestrian bridges • Upgrading roads around aggregate supply areas

Off-Site Traffic Planning Considerations:

- estimates of possible truck traffic volumes
- sensitive facilities (e.g., residences, schools, retirement homes, hospitals)
- low-ballast roads
- overgrown roadside vegetation affecting safety, visibility and pedestrians.
- preferred trucking route(s)
- reduced speed zones for aggregate traffic
- driver training and protocols
- signage and traffic control measures such as weight-activated turning lights
- enhanced pedestrian crossing aids
- roadside improvements (sidewalks, hedges or fences) and cost-sharing
- refusal to load rogue truck drivers
- avoiding overload
- wheel washers to remove dust and mud
- dust skirts on overhead loadout facilities to reduce dust generation
- preventing aggregate from landing on vehicle surfaces outside box, or sweeping off before hauling.
- covering or spraying loads to reduce blow-off.

5 - 5 STORMWATER & EROSION CONTROL MODULE - SECM

Common Concerns: Stormwater & Erosion Control

Without adequate stormwater or erosion protection measures, exposed soils have the potential to introduce large amounts of sediments and silts to both natural and manmade environments. Proper control of stormwater and erosion at aggregate operations may decrease the need for pre-discharge treatment of stormwater and decrease the likelihood of off-site environmental impacts, such as degraded surface waters and fish habitat. A *Mines Act* permit application (Notice of Work & Reclamation for a Gravel Pit or Quarry) requests a description of surface run-off and sediment control measures (schedule B). If stormwater is discharged to the environment, a *Waste Management Act* permit may be required, and if diversion ditches or settling ponds are constructed, a *Water Act* authorization may be required.

The geotechnical requirements of the *Health, Safety & Reclamation Code for Mines in BC* are designed to prevent landslides, slumps and debris flows caused by extreme stormwater and erosion from occurring at mine sites. This module will address the slower and less spectacular, yet potentially as damaging phenomena of unchecked erosion, transport and sedimentation of soils, silts and clays into surface waters and aquatic environments.

Stormwater and erosion control planning can help limit topsoil and fine product loss due to erosion by wind or precipitation, and reduce the amount of siltation, fugitive dust and exposed soils. Effective stormwater and erosion control practices keep working sites dry, which cuts operating costs through reducing wear and tear on equipment and tires, and lessens the need for pre-discharge treatment of storm water.

Stormwater planning can help to identify the stormwater management requirements of a site and the selection of BMPs for stormwater control. The scale of the stormwater planning should reflect the size and complexity of an aggregate operation. Stormwater planning can be as simple as stormwater BMPs sketched on a copy of the extraction map, or as comprehensive as a professional hydrological analysis.

Erosion control planning can help identify the location and character of the erosion hazards and risks on an aggregate site and assist in the selection of control methods. For both stormwater and erosion control, the basic control BMPs are:

- Bioengineering
- Buffer Zone
- Ditches
- Retention Basins
- Settling Pond
- Vegetation Cover
- benches
- hydroseeding
- swales
- treed wind breaks
- wetlands

Stormwater and Erosion Basics

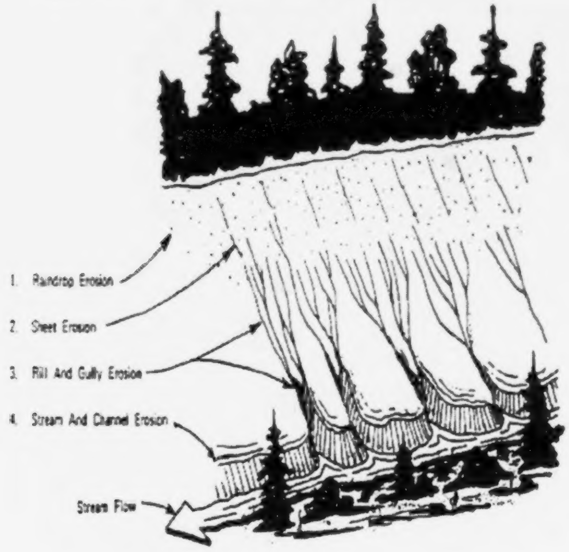
Stormwater

Stormwater is the portion of rainfall or snowmelt that does not immediately percolate into the ground or evaporate. Stormwater flowing across exposed soils can pick up fine clays and silts which, if not managed properly, may negatively impact offsite water quality.

Erosion

Erosion is the dislodgment, removal and loss of topsoil, silt or clay from its original location by water, wind, ice or gravity. At aggregate production sites, soil erosion is caused by vegetation removal, the exposure of soils to water, and to a lesser extent, wind.

Figure SECM - 1: Types of water erosion on soils (topsoil, silt and clay)



Types of Water Erosion	
Raindrop Splash Erosion	• The impact of falling droplets of rain mechanically dislodges soil particles causing them to be carried away by runoff.
Sheet Erosion	• Before concentrating into small channels, raindrop splash and runoff moves as broad sheets over the land and removes layers of exposed soil.
Rill and Gully Erosion	• As runoff concentrates in rivulets, it cuts grooves called rills. • If the flow of water is sufficient, rills will develop into gullies.
Stream and Channel Erosion	• Large volumes of fast flowing water in unprotected channels will cause stream bank and stream bottom instability, scouring, and removal of significant portions of the stream or channel banks and stream bottoms.

O'Brien, page 5.

Erosion Control Pointers

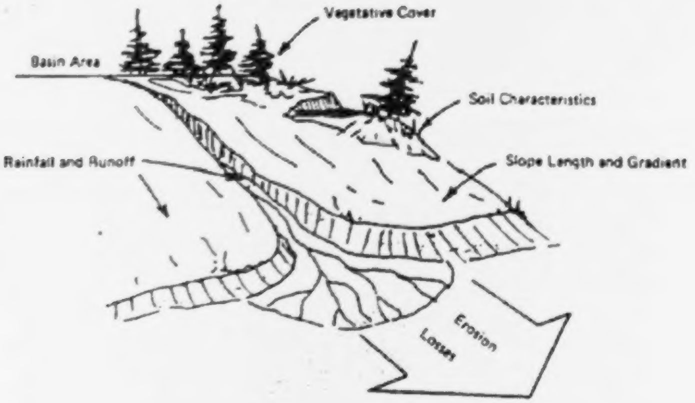
Keep Existing Vegetation Intact

Vegetation (Figure SECM - 2) plays an extremely important role in controlling erosion by:

- shielding the soil surface from the impact of falling rain,
- slowing the velocity of runoff, thereby permitting greater infiltration,
- maintaining the soil's capacity to absorb water, and
- binding soil particles to plant roots.

Erosion can be significantly reduced by limiting the removal of existing vegetation and by decreasing the duration of soil exposure to rainfall. Operators should retain existing vegetation on areas of high erosion potential such as erodible soils and steep slopes. If it becomes necessary to remove vegetation from these areas, revegetation should be done as quickly as possible thereafter. Interim measures could include covering the site with tarps, geotextiles, or straw.

Figure SECM - 2: **Effect of vegetation on stormwater runoff.**


Vegetative Cover
Basin Area
Soil Characteristics
Rainfall and Runoff
Slope Length and Gradient
Erosion Losses

O'Brien, 2001, page 9

Limit Slope Steepness & Length

Slope length and steepness are key elements in determining the volume and velocity of runoff and the degree of erosion. As slope length and/or steepness increase, the velocity of runoff and the potential for erosion also increase. An operator should limit slope steepness and length by either controlling grade or benching.

Managing Stormwater & Erosion

Aggregate operations expose soils as part of their day-to-day operations. Table SECM-3 lists a number of strategies, BMPs and other control measures that can be used to reduce stormwater and erosion risks posed by this exposure.

Table SECM - 3: **Strategies and BMPs for erosion and sedimentation control.**

Stabilization (prevention)	**Structural** (treatment)	**Inspections**
• Buffer Zone • Bioengineering • Ditches • Erosion Control Blanket • Tarp • Vegetation Cover • benching • hydroseeding • limit clearing • tree protection	• Check Dam • Ditches • Outlet Protection • Retention Basin • Settling Pond • Silt Fence • swales	• post - storm events • weekly

Stabilization Practices

Stabilization practices help prevent erosion and consequent siltation. Typical stabilization practices include hydroseeding, mulching, geotextiles, sod stabilization, buffers, protection of trees, preservation of mature vegetation and decreasing slope angles or lengths.

Structural Practices

Structural BMPs divert flows from exposed soils, store flows, or otherwise limit runoff and the discharge of sediments from exposed areas of the site. Such practices may include ditches, silt fences, earth dikes, drainage swales, sediment traps, check dams, slope drains, level spreaders, reinforced soil retaining systems and sediment basins.

Inspections

Erosion and sediment control structures are like mechanical equipment, and require regular attention to ensure proper performance. At active operations, visual inspections of on-site stormwater and erosion control measures can be made a part of general site inspections. A recommended schedule might be once every seven days, and within 24 hours after any storm event of greater than 1 cm of rain per 24 hour period. A log of these visual inspections, recording the date and pertinent observations (e.g., 12/7/99 - very heavy storm but no significant turbidity in runoff) can be kept and managed with other records.

Table SECM - 4 highlights stormwater and erosion control issues for aggregate operations and recommends BMPs and other control measures to reduce potential environmental impacts.

Table SECM - 4: Stormwater and erosion control issues for aggregate operations and recommended BMPs.

Component	Considerations & Suggestions	BMPs & Other Measures
Precipitation	• stormwater starts as rain or snow • contact the local office of the Ministry of Land, Air and Water for estimates of expected rainfall and wet seasons • rainfall estimates (seasonal & peak storms) multiplied by the surface area of the site will yield rough run-off volumes that can be used to set performance targets	
Adjacent Areas	• the type of adjacent land uses will determine runoff volumes; for example, hard surfaces such as parking lots will result in high runoff • stormwater flows from upslope or upstream may impact the operation if they pass through the property • where will the stormwater go once it leaves the site? What path will it take and what may it affect (streams, lakes, wetlands, residential areas, roads, etc.)?	• Risk Management Module, IPEI section.
Site Characteristics	• how does stormwater flow over the undisturbed site? • what existing onsite drainage features are significant, and can they be used to assist in managing stormwater? • what are the existing topography and vegetation, and how do they affect stormwater?	
Critical Areas	• some areas are more susceptible to impact from unmanaged stormwater than others, such as a salmonid stream • critical areas may include water wells, wetlands, riparian areas or fish streams	• Risk Management Module, IPEI section.
Soils	• where soils have not been stripped for aggregate extraction, they can play an important role in stormwater management by absorbing stormwater like a sponge • exposed and unprotected soils are highly susceptible to erosion by stormwater	• Erosion Control Blanket • Silt fence • Tarp • Vegetation Cover
Erosion Problem Areas	• size, shape, steepness and slope length can make some areas more susceptible to erosion than others • some topsoil, silt and clays are more susceptible to erosion due to their composition	• Erosion Control Blanket • perimeter planting
Clearing, Grubbing and Stripping	• clearing, and especially grubbing, expose soils to stormwater and erosion, potentially causing siltation • limit the extent of clearing and grubbing to what is immediately necessary • clearly mark clearing boundaries to avoid inadvertent excessive clearing	• Preserve Natural Vegetation
Ditches	• divert surface flows around/away from exposed soils (*Water Act* approval required) • convey stormwater around the property • channel water into sediment basins	• Ditches • swales
Flow Controls	• slower water flows have less energy to cause erosion and transport sediment • check dams, swales, retention basins and vegetation can decrease flow rates within ditches • divert runoff away from exposed areas wherever possible	• Check Dam • Retention Basin
Source Control of Pollutants	• preventing pollutant release through source control BMPs is preferred over treatment (e.g., oil/water removers). • refer to the Risk Management Module for a discussion of pollution prevention	• Oil/Water Separator • covered storage
Sediment Control	• sediment free stormwater is the goal of stormwater management • minimize the amount and rate of runoff and that will reduce sediment entrapment • remove any entrained sediment from the stormwater using swales, retention basins and silt traps before discharging	• Retention Basin • Silt Fence • Wheel Washer
Stabilize Soils	• exposed soils can be eroded by raindrop impact and flowing water • preserve existing vegetation and/or establish new ground cover • exposed soil stockpiles can be covered with tarps	• Erosion Control Blanket • Tarp • Vegetation Cover
Protect Slopes	• stormwater flowing down slopes picks up speed (energy) increasing its ability to cause erosion and pick up sediment • minimize slope length and steepness with terracing and diversions • divert runoff around the top of a slope • slopes can be protected with hydroseeding, erosion control blankets and tarps.	• Bioengineering • Erosion Control Blanket • Tarp • Vegetation Cover
Discharge	Stormwater discharge options include: 1. Recycle into processing water 2. Land application (field application, irrigation, level spreader, swale) 3. Surface water application (see Water Quality Guidelines)	• French Drain • Retention Basin

Stormwater & Erosion Control Maps

Stormwater and erosion control (SEC) maps are not generally required for a *Mines Act* permit, but can be a useful tool to summarize and illustrate how stormwater flows over a site, potential erosion prone areas, and measures used to control flows and erosion. A SEC map would also fulfill the Notice of Work & Reclamation for a Gravel Pit or Quarry requirement to show on a map "watercourses and drainages (wet, dry or intermittent) on the property and within 150 meters of its boundaries."

Table SECM - 5: Suggested features for a stormwater & erosion control map.

Stormwater Plan Map Checklist	
Exposed Soil	• show areas where soils are currently exposed, by natural processes or by current or previous work • steep or long slopes • exposed soils • erodible soils • proposed clearing sites
Vegetation	• indicate existing tree lines, ground cover and grassy areas on the site that can be used to help control stormwater
Erosion Problem Areas	• identify potential erosion problem areas
Critical Areas	• identify any on-site and adjacent critical or sensitive receiving areas such as water wells, wetlands, riparian areas, fish habitats and streams
Adjacent Areas	• indicate if stormwater may come onto the site from adjacent areas • indicate where the stormwater will go if it leaves the site • indicate what may be affected (e.g., streams, lakes, wetlands, residences, etc.)
Drainage Areas & Patterns	• show how stormwater currently flows about the property • identify collection areas (often called basins or watersheds), waterways and natural discharge points
Clearing Areas	• show areas that are to be cleared, grubbed and stripped
Ditches	• show on the map the following ditches: 1. diversion ditches to divert stormwater away from extraction, stockpiling, problem and cleared areas, and roads 2. conveyance ditches that move stormwater around the site (e.g., to sediment basins or other control features)
BMPs	• plot location of BMPs (ditches, checkdams, swales, vegetation, bioengineering, retention basin, etc.) • BMP infosheets in chapter 7 of this handbook have map codes in their top left hand corners for this purpose

After: O'Brien, 2001, pages 36-38.

5 - 6 BY-PRODUCT & WASTE MODULE - BWM

Common Concerns: Aggregate By-products & Waste

Most aggregate operations generate by-products and waste that, if not managed expediently, can cause space control problems, add to costs and potentially be detrimental to the environment.

Aggregate by-products are overburden that is moved in order to access resources, screenings and settling-pond fines. These by-product materials are generally of low unit value, and extra handling to dispose of them represents added costs. Where markets can be found for by-products, cost recovery is often the best that an operator can anticipate. Finding timely and effective uses or applications for aggregate by-products can be a challenge for many operators.

Waste generated at aggregate sites generally includes garbage, used petroleum products and other non-mineral materials. Effectively managing waste means reducing its production, planning for the space and containment to adequately handle the material, and arranging for cost-effective and appropriate disposal in accordance with applicable regulations. Planning to handle waste properly and promptly may prevent subsequent time-consuming and costly remedial action.

Sand and gravel pits are often located in areas of high permeability, sometimes even in groundwater recharge areas. Waste management at these sites should recognize and account for the greater risk associated with high permeability areas. Furthermore, aggregate operations should handle waste in a manner that will not negatively impact subsequent land uses.

Planning for by-products and waste management includes identifying the types and volumes of produced materials, developing procedures for handling these materials, and finding applications or depots for their disposition. Minimizing handling will benefit both the producer and the end user.

This module recommends four basic strategies of by-product and waste management:

- minimizing their production,
- planning for space to handle/store them,
- finding uses or destination sites, and
- minimizing handling.

What Are Aggregate By-products

By-products at aggregate operations are any materials that are not sold as a primary product. Table BWM - 1 lists and describes some by-products. Note that topsoil is not generally considered to be either a by-product or a marketable product, and often has to be saved on the site for reclamation.

Table BWM - 1: Potential by-products generated at aggregate operations

Aggregate By-products	
Overburden	material below topsoil and above salable gravel and rock
Oversized/ Coarse Rock	boulders, cobbles, etc. that are removed by screening
Clay	layers sometimes found within the mining sequence
Wash Plant Fines	silt, sand and clay
Sediment Pond Fines	silt, sand and clay
Screenings/ Undersized Material	natural sands, dirty sands, undersized material
Baghouse Fines	silt, sand and clay
Grubbing Material	stumps, woody debris, slash

By-products Are Not Waste

Aggregate by-products do not generally fall under the definition of waste as defined in the *Waste Management Act*. There are a few circumstances where the chemical properties of naturally occurring rock, when exposed to air and water, produce effluent (i.e., substance capable of damaging the environment). This material may be classified as waste and fall under *Waste Management Act* regulations for handling and disposal.

By-Product Storage Options

Aggregate by-product storage options include stockpiles, pre-cast locking concrete block corrals, and bags (from a bag house).

Table BWM - 2, outlines types of aggregate by-products, their production, significance, storage options, potential uses and BMPs.

Table BWM - 2: Aggregate by-products significance, storage and application options

By-product	Production	Significance	Storage	Possible Uses and Applications	Suggested BMPs & Other Measures
Overburden	**Periodic** - only during stripping	Overburden depths vary throughout the province. May be clay rich, leading to erosion concerns.	• stockpile • berms	• used for reclamation fill • sold as fill • used to make berms	• Berm • progressive reclamation
Oversized Rock	**Continuous** - during normal extraction	Not all sand and gravel deposits have a significant coarse component, and it may vary throughout the deposit.	• stockpile • berms	• stockpiled and crushed • sold as rip rap • sold as fill • used as reclamation fill • sold as landscaping material • used in stream rehabilitation programs • used for on-site erosion control	• Berm • progressive reclamation • habitat enhancement
Clay	**Periodic** - only when present and during extraction	Not all sand and gravel deposits have a significant clay content, and it may vary throughout the deposit.	• stockpile • berms • cover to minimize erosion (plastic, geotextiles, soil, vegetation)	• used for reclamation • made into perimeter berms and vegetated • sold as fill • sold as landfill liner & cover material • sold as a soil supplement for agricultural applications	• Berm • progressive reclamation
Wash Plant Fines	**Continuous** - during normal processing activity	Not all operations wash aggregate. Also depends on fine content of deposit, washing equipment and process efficiencies	• in situ ponds • holding cells	• sold as agricultural supplement • used for reclamation fill • used for growth medium during reclamation	• growth medium supplement • progressive reclamation
Sediment Pond Fines	**Variable** - during normal processing activity and during the storm season	Depends on rainfall and fine content of deposit.	• in situ • holding pen	• sold as agricultural supplement	• growth medium supplement • progressive reclamation
Baghouse Fines	**Continuous** - during normal processing activity	Baghouses are large vacuum systems used to extract dust from enclosed processing operations. They are not commonly used in BC.	• bags	• used for asphalt mineral filler • sold as a soil supplement for agricultural applications • used for reclamation fill • used for growth medium during reclamation	• growth medium • progressive reclamation
Grubbing Materials	**Periodic** - only during stripping	Not generally a significant amount of material.	• stockpile (not chipped material)	• harvest of merchantable timber • burned • chipped • chipped and blended with soil • buried (with permission) • hauled off-site • spread off-site on right-of-way • composted • mixed in berm material	• compost • engineered wildlife trees • growth medium • habitat enhancement • progressive reclamation

What Are Aggregate Wastes

The *Waste Management Act* defines waste to include air contaminants, litter, effluent, refuse, biomedical waste, special wastes, and anything else designated by the Lieutenant Governor in Council. More precise definitions of air contaminant and effluent are provided in Table BWM - 4. Table BWM - 3 lists common aggregate operational wastes with a brief explanation of each.

Table BWM - 3: Potential types of general wastes at an aggregate operation

Common Aggregate Wastes	
Used Oil	used engine oil and hydraulic fluids
Site garbage	garbage from office building, vehicle maintenance, lunch room, etc.
Septic Effluent	sewage
Decommissioned Equipment	major equipment and attachments
Used Barrels	oil, lubricants, surface treatments

For the most part, litter and refuse at aggregate operations can be collected and disposed of through conventional means. There may be some circumstances where local litter and refuse disposal sites are not available and where a general waste disposal permit for litter and refuse may be required.

For discharges into air and water, the regulations of the *Waste Management Act* set allowable discharge limits. If discharges into air or water exceed those levels, a waste permit may be required.

Table BWM - 4: Definition of "air contaminant" and "effluent"

"air contaminant" means a substance that is emitted into the air and which	**"effluent"** means a substance that is discharged into water or onto land and which
(a) injures or is capable of injuring the health or safety of a person, (b) injures or is capable of injuring property or any life form, (c) interferes or is capable of interfering with visibility, (d) interferes or is capable of interfering with the normal conduct of business, (e) causes or is capable of causing material physical discomfort to a person, or (f) damages or is capable of damaging the environment;	(a) injures or is capable of injuring the health or safety of a person, (b) injures or is capable of injuring property or any life form, (c) interferes or is capable of interfering with visibility, (d) interferes or is capable of interfering with the normal conduct of business, (e) causes or is capable of causing material physical discomfort to a person, or (f) damages or is capable of damaging the environment;

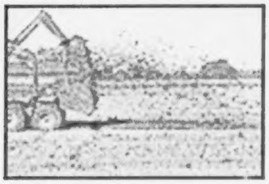
Province of British Columbia, Waste Management Act section (1)

Special wastes are defined in the Special Waste Regulation (http://www.qp.gov.bc.ca/statreg/reg/W/WasteMgmt/WasteMgmt63_88Special/63_88.htm). Two common special wastes that may be found at aggregate sites are used oil and surplus pest control products and their containers. Common aggregate operation materials that are not considered special wastes are asphalts and tars, and wood products treated with preservatives or wood protection products registered under the *Pest Control Products Act* (Canada).

Managing Aggregate By-products

If a use, application or destination for materials can be found ahead of time, primary handling during extraction or processing can move that material directly to its final destination, avoiding double handling.

Image RWM - 5: Spreading muck for an agricultural application



Minimizing Production of Aggregate By-products

Options for minimizing by-product production include:

1. Only strip areas of overburden where extraction will immediately take place
2. Avoid extraction of particularly clay-rich materials if site conditions permit selective mining
3. Tune processing plant for maximum recovery of salable fines to avoid including them with wash plant fines

Planning for Sufficient Handling and Storage Space

Refer to the Stockpiling Module for advice on space allocation for storage and handling requirements for all materials on an aggregate production site.

Finding Uses for Aggregate By-products

1. Immediate On-Site Uses/Applications

Options and locations for usage/applications of aggregate by-products should first be sought at the aggregate production site. Progressive reclamation is an ideal application for overburden and by-product rock that can be immediately directed to the reclamation area as part of the extraction or processing operations. Other options include berm construction, soil treatments and progressive reclamation grading.

2. Immediate Off-Site Uses/Applications

A second option for managing aggregate by-products is immediate off-site application. If an off-site use/application is pre-arranged, by-product material can be taken to that site as it is produced. This approach reduces the need to stockpile and double handle by-product material at the aggregate operation. Off-site application may also be viable for limited wastes, such as used equipment and scrap iron.

Options for use or disposal of aggregate by-products are only limited by time, effort and resourcefulness. A potential resource for locating uses for by-product materials is the Recycling Council of British Columbia (RCBC). One of their programs, the BC Materials Exchange (MEX), provides a way for suppliers and users of low-valued materials to find each other. MEX's motto is "one company's garbage is another's gold." Contact information is in Figure BWM-6.

Figure BWM - 6: Recycling Council of British Columbia contact information

Recycling Council of British Columbia (RCBC)	
Greater Vancouver:	R-E-C-Y-C-L-E (732-9253)
Anywhere in BC:	1-800-667-4321
Hours:	Monday to Friday, 9:00 AM to 4:00 PM.
Web Address:	www.rcbc.bc.ca

3. On-Site Storage with Delayed Uses/Applications

A third option for managing by-product materials is to store the materials on site until a use/application can be found. Table BWM - 2 outlines storage options for various types of aggregate by-product. The main drawbacks of this option are the space requirements and the costs of storage and double handling of the material. There is also the risk that a use may never be found.

Managing Aggregate Wastes

Key advice for managing aggregate wastes is,

- reduce waste production
- plan for handling space and adequate containment
- recycle or dispose
- minimize handling

With the proliferation of recycling options and restrictions, locating facilitates to accept wastes can become time-consuming. Table BWM - 7 outlines handling options for various types of aggregate wastes.

Table BWM - 7: **Aggregate wastes and handling options**

Waste	Production	Notes	Storage	Disposal Options
Used Oil	**Continuous** - product of regular maintenance	- recycling of used oil is required by law and is a well established practice in BC	- barrels	- return to seller[1] - collected by recycler
Site Garbage	**Continuous** - product of regular business	- recycle office paper, plastic containers and glass bottles	- dumpster - recycling bins	- dumpster pickup - burning - recycling
Septic Effluent	**Continuous** - if municipal sewer system is not available	- portable and permanent septic solutions are readily available	- septic field - holding tank	- septic field -- ref. Ministry of Health - pumped out
Decommissioned Equipment	**Periodic** - decommissioning of major equipment is relatively rare	- dependent upon local market for used equipment or scrap metal recycling facilities	- yard	- sell as used equipment - sell as scrap - sell for parts - remove to appropriate waste disposal site.
Double Walled Enviro-Tanks	**Periodic** - only as bulk-supplied products are used			- return for deposit - give to barrel dealer

Waste management planning for aggregate operations can include the planning of "how to reduce," "whether to recycle or dispose," and "how to handle waste." For garbage, a pickup service may be hired where available. Otherwise, delivery to a collection point or disposal site may be required, and in some jurisdictions burning is still an option. For human sanitary facilities, a permanent "park-type" outhouse facility with tank, portable toilets, or conventional flush toilets can be used. B.C. Parks has standard drawings for the construction of proper outhouse facilities. The petroleum products supplier may offer a pickup service for used oil, or the used oil may carefully be stored in drums on site until sufficient volume accumulates for delivery to a recycling depot.

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[1] Note: see "Return of UsLubricating Oil Regulation," 1992

5-7 SITE LAYOUT MODULE - SLM

Common Concerns: Site Layout

Site layout choices can have a strong influence upon the potential community impacts of an aggregate operation, particularly where it concerns noise, dust and visual aesthetics. This module discusses, in separate sections, site layout with respect to controlling noise, dust and visual landscape impacts and recommends that a Site Layout Map be constructed to help understand and address these concerns.

Noise

Noise is one of the most commonly cited community concerns regarding aggregate operations. As Table MP - 4: Mine Plan Activity And Module Worksheet in Chapter 4 indicates, noise is associated with a great number of common activities at aggregate operations, including blasting, loading, crushing, screening, washing and hauling. This module will assist in identifying noise point sources at aggregate operations and BMPs and other measures that can be used to minimize noise.

Dust

In both urban and rural environments, neighbours of aggregate operations commonly voice concerns about dust. The disturbance of fine soils by extraction and processing activities at sand and gravel pits and rock quarries increases the potential for dust creation, and dust control should be part of ongoing operations. This module will assist in identifying dust-generating activities, situations where dust can be an issue, which people and facilities are sensitive to dust, and what BMPs and other measures can be used to control dust.

Visual Landscape Design

An aggregate operation's appearance may significantly affect the relationship between the aggregate operation and its host community. With increasing environmental and public land use interest in the aggregate industry, managing the appearance of an operation has become an important priority. Visual landscape planning can help to strike a balance between the aesthetic concerns of the community and the economic and operational validity of the operation.

Through the provincial land use planning process, the Province is currently performing a Visual Landscape Inventory. This process involves establishing visual quality objectives, classifying landscapes and designating significant scenic areas. In some areas of the province, visual quality objectives may have to be met for a subsequent permit to be granted, similar to a licence to cut for forestry activities. With British Columbia's world-renowned landscapes proclaimed on every licence plate, and with the developing of the tourist and movie industries, viewscapes are regarded as a provincial resource that, where possible, should be considered at aggregate operations during their productive life spans.

Section 1 - Noise

Aggregate Operation Noise Management

Planning to manage noise at an aggregate operation can include:

- identifying activities that generate noise,
- determining how the configuration of the property amplifies, muffles or reflects noise,
- developing measures and BMPs to reduce noise generation, and
- developing measures and BMPs to reduce the transmission of noise.

Understanding Noise

The intensity of sound is measured in units called decibels (dB) and is expressed on a logarithmic scale. As such, combining sound levels is not a matter of simple addition. For example 50 dB + 50 dB = 53 dB, not 100 dB. An increase of 3 dB in sound intensity doubles the sound energy, or loudness. Likewise, a 12 dB increase in intensity represents an 800% increase in loudness.

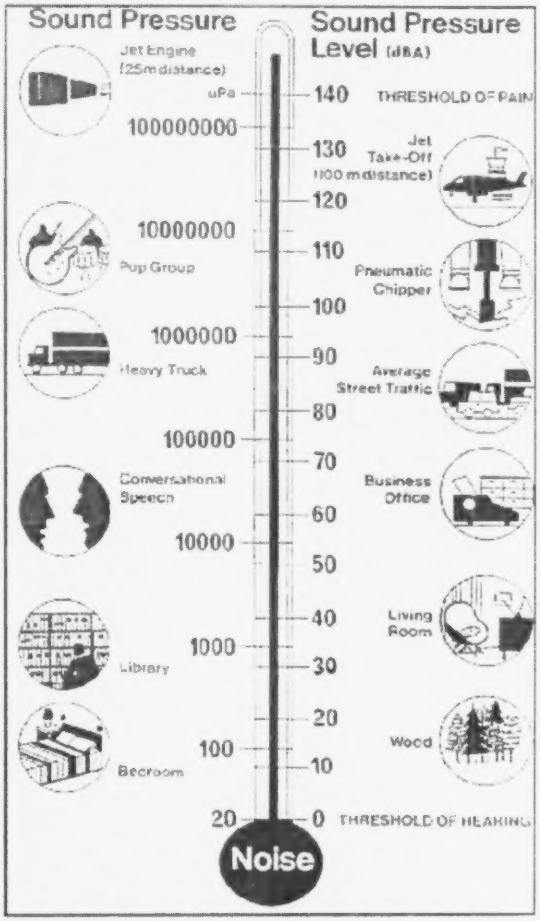
Different criteria are used to measure sound for different purposes. Criteria used to approximate the sounds heard by the human ear, called "A-weighting", are recorded in dBA. Other measuring options include comparing sound levels over time (Leq), measuring its steady state, or measuring the peak (impact) level.

Noise sources at aggregate operations can include equipment engines, back-up alarms, drills, power generators ("gen sets"), crushers, screens, material falling on to a grizzly or into the empty metal box of a haul truck, the 'body slap' of empty truck boxes, squealing of tracked vehicles, and even the rattle of loose hitches or boxes on trucks travelling through the neighbourhood. Noise control can include scheduling hours of operation, selecting appropriate equipment (e.g., does it have a proper muffler?), constructing sound barriers and berms to contain noise and other options.

The effects of aggregate operational noise on neighbours can vary, but may cause annoyance, disturbance and even a sense of interference with quality of life. Factors to consider include hours of operation (especially early morning), frequency of vehicle traffic on local roads, steps taken to contain noise emissions and, of course, how close the operation is to neighbouring houses.

Wildlife, livestock and even fish may also be affected by noise exposure. Fisheries and Oceans Canada's (DFO) *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* recommends set-back distances for specific substrates and weights of explosive charges (Wright and Hopky, 1998).

Figure SLM - 1: Noise levels from common sources



BC Ministry of Energy and Mines, 1998 , pages 2-9.

Table SLM - 2: Projected un-buffered noise levels for some common aggregate machinery.

Table 3.1. Summary of noise measurements and projected noise levels in decibels (dBA) for common mining equipment (Barksdale, 1991)

		Projected noise levels		
Noise source	Measurements	1,000 ft	2,000 ft	3,000 ft
Primary and secondary crusher	89 dBA at 100 ft	69.0 dBA	63.0 dBA	59.5 dBA
Hitachi 501 shovel, loading	92 dBA at 50 ft	66.0 dBA	60.0 dBA	56.5 dBA
Euclid R-50 pit truck, loaded	90 dBA at 50 ft	64.0 dBA	58.0 dBA	54.4 dBA
Caterpillar 988 loader	80 dBA at 300 ft	69.5 dBA	63.5 dBA	60.0 dBA

Norman and others, 1997, page 3-8.

Table SLM - 3: Common noise generating activities at aggregate operations

Activity	Duration (D) & Potential Impact (I)	Noise Producers	Suggested BMPs & Noise Reduction/Control Methods
Tree Removal, Grading and Topsoil & Overburden Handling	D - Intermittent and temporary I - Medium	moving vehicles such as skidders, bulldozers, haul trucks, excavators and chain saws	• Berm • Environmental Timing Windows • Equipment Selection • equipment maintenance
Drilling and Blasting	D - Intermittent I - Low	drilling rig, power plant for drilling rig, moving the rig, detonation	• Environmental Timing Windows • Equipment Selection • electronic detonators
Extraction & Handling	D - Moderate I - Moderate	moving vehicles such as front-end loaders, excavators, bulldozers and haul trucks	• Berm • Environmental Timing Windows • Equipment Selection • Fences
Processing & Crushing	D - Continuous I - High	loaders to feed crushers, haul trucks to deliver material to the crusher and remove crushed material; powering of crushing plant (primary and secondary); crushing of material; excavator-mounted hydraulic hammers to pre-crush large rocks	• Berm • Environmental Timing Windows • Equipment Selection • Fences • acoustic screens • barriers/ • enclosure • line hoppers • location • start plants one at time
Grading	D - Intermittent I - Medium	bulldozers, haul trucks, excavators, graders and scrapers	• Environmental Timing Windows • Equipment Selection
Stockpiling	D - Continuous I - Low	moving vehicles such as front-end loaders, bulldozers, haul trucks and conveyors to build stockpiles	• Environmental Timing Windows • location
Conveying	D - Continuous I - Medium	powering of conveyors, roller noise, belt slap and material fall noise	• Drop Height • Environmental Timing Windows • chutes • enclose conveyor • maintenance
Onsite Transport - Truck	D - Continuous I - Low	haul trucks	• Environmental Timing Windows • Equipment Selection • alternative reversing alarms • locate haul roads at lowest elevation. • speed limits
Loading	D - Intermittent I - Low	front-end loaders, material drop noise and honking, material falling onto grizzly	• Drop Height • Environmental Timing Windows • Equipment Selection • equipment maintenance • rubber linings • slide or slowly rotate material into truck boxes

After Cole and others, 1999

Common Aggregate Operation Noise Considerations

Noise management planning may benefit from the following notes in determining the degree of noise control necessary for an aggregate operation.

Existing Noise Levels

The background noise levels around a site can be considered to help determine noise emission targets for an aggregate operation. Aggregate operations within an industrial park or remote forested area will have less noise concerns than operations within urban and rural areas. Noise-sensitive neighbours might include residences, churches, schools, hospitals or other health care institutions, intensive livestock farms, tourist oriented resorts and some factories. Neighbours and sites that are more noise sensitive in general will have a lower tolerance threshold for noise generated from an aggregate operation.

Site Location

Noise emissions can be either dampened or reflected by vegetation and by the land itself. Hard ground such as paved or non-vegetated areas and water surfaces reflect sound very well, whereas soft ground such as grassland, wood lots and cultivated fields absorb sound. Hillsides or cliffs can also reflect sound above the ground surface to where it can be heard for significant distances. For example, operations perched on a hill slope overlooking a large lake may have to pay particular attention to controlling the noise reflection. Alternatively, berms and trees can be used to deflect and/or absorb noise, blocking the straight line by which sound travels (i.e., noise pathway).

Climatic conditions can also affect noise impacts to a limited degree and can be taken into account in the planning stages for an aggregate operation. Low cloud cover can reflect noise back to the ground and prevent upward dissipation. During winter months, the cooling of air increases its density, thus increasing both transmission speed and distance travelled. Prevailing winds can extend noise downwind and reduce transmissions upwind. Precipitation and humidity both reduce noise propagation as the water particles absorb noise energy.

Equipment and Activities

For any type of equipment that an aggregate operation uses, some models are quieter than others. Noise level emissions can be used as one of the criteria when selecting equipment.

Stationary noise-generating equipment and activities can be acoustically contained. Options for containing noise range from local acoustic fencing and shielding to enclosure within a building. The Chief Inspector of Mines will consider a written application for a *Mines Act* variance to replace back-up alarms on mobile equipment with back-up strobe lights.

Site Layout and Plant Location

Where flexibility exists, strategic placement of activities can reduce the level of noise emanating from a site. Locating noise-generating activities as low on the property as possible may allow their noise emissions to be absorbed and blocked by the land. Similarly, crushers and haul roads can be located away from sensitive receptors and exposed locations.

Berms, tree barriers and acoustic fences can be used adjacent to sensitive noise areas or as a perimeter measure to contain noise within the operation's boundaries. A technique commonly used for aggregate operations is to construct an acoustic fence using surplus conveyor belts on a sturdy frame. The weight and flexibility of the belting provides excellent noise absorption.

Noise Management

Working with the Public on Noise Management

It is important for the public to sense that an aggregate site operator is committed to the mitigation or avoidance of noise impacts. Opportunities should be taken to discuss the results of noise monitoring (e.g., when, for how long and why particularly noisy events are likely to occur) with local communities.

Figure SLM - 4: Noise attenuation provided by different barriers

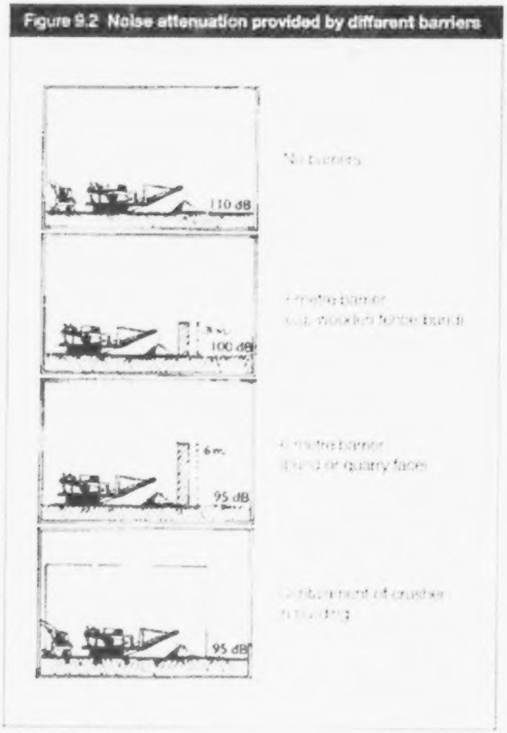


Figure 9.2 Noise attenuation provided by different barriers
110 dB
No barriers
3 m
100 dB
3 metre barrier
(e.g. wooden fence bund)
6 m
95 dB
6 metre barrier
(bund or quarry face)
95 dB
Containment of crusher
in building

Cole and others, 1999.

Some operators have successfully implemented community response systems to address noise-related complaints in a fair and expedient manner. A record of complaints, the actions taken, outstanding follow-up actions and subsequent dialogue with complainants are some measures that have been practiced with success.

Methods For Reducing And Controlling Noise

Noise can be controlled at aggregate operations by a number of strategies such as:

- source control,
- containment,
- site layout (stationary objects),
- operations (activities or moving objects) and
- interception (perimeter structures).

Careful site planning can help to contain the noise with the use of the existing topography, existing and introduced vegetation, major landscaping (berms), acoustic fences, tree barriers and combinations of these methods. Operational practices can reduce both the generation and the escape of noise. Finally, interception can be achieved with property edge treatments such as perimeter barriers composed of trees and shrubs or acoustic fences specifically designed to intercept ambient noises. Table SLM - 5 outlines these suggestions with associated BMPs.

Noise Planning Considerations

Noise planning for an aggregate operation encompasses both the planning of the site layout and the development of operational procedures. Although a Site Layout Map is not generally a permit requirement, the plan for noise (as well as dust and visual) considerations could be worked out and documented on such a map. A Site Layout Map could contain the following noise components:

- noise-generating activities,
- off-site facilities that are noise-sensitive ,
- potential noise reflectors (mine faces, hillsides, hard ground and water), topographic hollows and noise absorbing areas (wood lots, shrub areas, grasses),
- placement of berms, stockpiles and tree buffers to create or enhance noise-dampening locations for the site or to act as noise barriers,
- plans to locate noise-generating activities and haul roads in suppressing locations and away far from noise-sensitive facilities,
- procedures to avoid noise generation and contain noise, and
- Designation of existing trees and shrubs as perimeter barriers on noise sensitive sides of the operation.

Table SLM - 5: Site layout, operations and interception noise control options

Management Options	Noise Management and Control Methods	BMPs & Measures
SITE LAYOUT **Containment & Dampening**	• locate haul-roads away from ridge tops and in topographic lows • place processing equipment within natural or excavated hollows, such as the pit or quarry floor • minimize the fall height of material • construct stockpiles to intercept point source and ambient noise • use crushing and screening plants within their design capacity • plan orientation of working faces to reflect noise into dampening areas • use first stage operations to act as screening for noise sensitive areas and receptors • group and position buildings to act as an acoustic barrier • restrict noise generating activities to sheltered areas • create 'sensitive zones' within which activities are limited	• Berm • Drop Height • Fences • Vegetative Cover • Straw Bale Wall • Treed Windbreaks
OPERATIONS **Source Prevention & Escape**	• select low noise emission equipment • ensure smooth road running surfaces • start plants engines one at a time • maintain, repair and lubricate equipment • alert and train staff to reduce noise emissions • limit drop heights during handling • fit acoustic barriers to processing equipment • minimize mobile equipment speeds • use alternative non-audible back-up alarms • vegetate exposed surfaces such as overburden mounds with quick growing ground cover and plants • use rubber linings in chutes, dumpers and transfer points to reduce the noise of rock falling onto metal surfaces • use simple baffles around washing drums and rubber mats around screening, crushing and coating plants • switch off equipment when not in use • avoid unnecessary revving of engines • direct noise away from sensitive areas whenever possible, if the noise source is highly directional • enclose sources of significant noise, such as conveyors and process plants • keep truck tailgates closed where possible	• Drop Height • Equipment Selection • Fences • Vegetative Cover • Water Spray • Speed Limits
INTERCEPTON **Ambient Reduction**	• retain and plant trees or shrubs around the site • place treed berms near noise generation activities (source), receptors or at the perimeter of the site • install acoustic fencing • ensure there are no gaps in acoustic barriers, as noise will leak out	• Berm • Fences • Perimeter Planting • Vegetative Cover

After Thomas, 2000

Section 2 - Dust

Understanding Dust

Dust is any particle up to 75 microns (µm) in size. A micron is one millionth of a metre. Particles larger than this are called "grit." Dust has a wide variety of man-made and natural origins including vehicle exhaust, agriculture, tire wear, natural and domestic fire and sea salt. Dust can become airborne by wind blowing over exposed surfaces or by mechanical disturbances such as rolling truck tires. Smaller sized dust particles travel farther and are a greater health concern that larger ones.

The most difficult type of dust to control is "fugitive" dust, which is generated by unstable, non-point sources (like movement of equipment) and the effects of wind on stockpiles and areas stripped of vegetation. Fugitive dust is the most common cause of dust complaints at aggregate operations, as it commonly settles on cars and in homes in adjacent areas (Thomas 2000). As Table SLM - 6 illustrates, mining and quarrying operations contribute only a small portion of all fugitive dust in the PM_{10} (smaller than 10 µm) size range.

Table SLM - 6: Example statistic of fugitive dust sources in the USA

Sources of Fugitive Dust (PM_{10})	Percentage of Total Dust Generation
Unpaved roads	28 %
Construction	23 %
Agriculture	19 %
Paved Roads	15 %
Wind Erosion	5 %
Mining/Quarrying	1 %

Goff , 1999, page 88.

Size Fractions of Aggregate Dust

Air quality concerns are often in the news and many cities report daily air quality indices. When the media discus dust, they are usually referring to PM_{10} (particulate matter smaller than 10 µm) or $PM_{2.5}$ (smaller than 2.5 µm) size fractions from all sources. As Table SLM - 7 shows, only about 6% of dust particles generated at aggregate operations falls into this category. No two sites will be identical and these percentages will vary depending upon site characteristics.

Table SLM - 7: Common concerns with aggregate dust by size category.

Dust Size Categories	Size µm (Micrometers)	Concerns	Percentage
Large Dust	10 - 75 µm	Nuisance	94 %
PM 10	2.5 - 10 µm	Health (respiratory)	3 %
PM 2.5	Smaller than 2.5 µm	Health (respiratory)	3 %

Barksdale, 1991.

Dust Generation

The amount of dust generated at an aggregate operation depends upon the site conditions, climate, nature of the material and site operations. As an example, Table SLM - 8 illustrates the results of a preliminary study at American sites of how much dust can be generated by the activities of loading, transporting and reclaiming stockpiles, versus simple wind erosion.

Table SLM - 8: Sample study of USA dust emissions from aggregate storage

Source Activity	% Total Emission	Emission Factor (Kg dust/ tonne aggregate)
Loading into storage	12	0.016
Transportation	40	0.050
Reclaim from stockpiles	15	0.020
Wind erosion	33	0.045

After Cole, 1999.

At an aggregate operation, dust can be generated from numerous conditions, including:

- **Wind**, blowing over exposed soil or stockpiled material (which includes material travelling in trucks or on conveyors, where the material is moving versus the air moving)
- **Falling Material**, such as in loading
- **Ground Abrasion**, where wheels and tracked vehicles kick up dust
- **Handling**, as in extraction, crushing and sizing
- **Drilling and Blasting**

Table SLM - 9 illustrates, common dust generating activities at aggregate operations, each activity's duration and potential to generate dust, reduction and control methods and associated BMPs.

Table SLM - 9: Common dust generating activities at aggregate operations and suggested controls measures

Activity	Duration of Activity	Potential Dust Emission for Uncontrolled Activity	Key Reduction and Control Methods	BMPs & Measures
Topsoil & Overburden Handling	• short • periodic	depends on moisture, silt and clay content of the material and transportation to stockpiles on the site, particularly during the unloading and haulage stages	• restrict the duration of stripping to the immediately necessary period • seal and seed surfaces and disturbed areas as soon as is practicable • protect exposed material from wind with covers (tarps), within voids or by topographical features • spray exposed surfaces of mounds regularly to maintain surface moisture • minimize handling	• Tarp • Vegetative Cover • Water Spray • handling • sealing • Wind Protection
Drilling and Blasting	• short • may be frequent	properly designed and controlled blasts create less dust	• use dust extraction equipment on drilling rigs • drill using water	• dust extraction/filters • dust removal
Extraction & Handling	• long • can be continual	depends on the equipment and technique used, content of material and exposure of the face	• keep working faces as small as possible • reduce drop heights wherever practicable • orientate face to reduce impact of prevailing wind	• Drop Height
Loading	• ongoing during extraction	depends on the nature of the material, whether it is wet or dry, volumes handled and equipment used	• reduce drop heights wherever practicable • protect activities from wind	• Drop Height • Wind Protection
Processing: Crushing & Sizing	• ongoing	depends on type of equipment, exposure to wind and fine contents of material	• enclose crushers and use bag house • use backstops for wind protection • use water sprays	• Wind Protection • Water Spray • enclosure
Stockpiling	• ongoing	depends on the volume and particle size of stored material, whether it is wet or dry and exposure to wind	• dampen material • protect from wind or store under cover • screen material to remove dusty fractions prior to external storage	• Tarp • Water Spray • screen out fines
Conveyor Transport	• ongoing	depends upon the conveyor system, nature of material and exposure to wind	• protect by use of wind and roof boards • shelter transfer points from wind • use scrapers to clean belts and collect scrapings for disposal • minimize drop heights and protect from wind • use water sprays	• Drop Height • Wind Protection • belt cleaning • roof boards
Transport - Onsite Truck	• ongoing	depends on type of road surfacing, road location and size and speed of trucks	• restrict vehicle speed • pave, water or treat roads • wheel or body wash at an appropriate distance from site entrance • load and unload in areas protected from wind • minimize drop heights • sweep paved roads	• Drop Height • Street Cleaning • Water Spray • Wheel Washer • sheet vehicles • speed limits
Transport - Off-site Truck	• ongoing	depends on road, speeds and truck equipment	• use sheeting or tarps • wheel or body wash at an appropriate distance from site entrance • use road sweeping • do not overload	• Street Cleaning • Wheel Washer • bucket covers

Thomas, 2000.

Dust Travel Distances

The distance that dust travels depends upon particle size and wind velocity. The smaller the dust particles the longer they can remain airborne and the wider the area over which they can disperse and deposit. Research has shown that the large dust particles (greater than 30 µm), which make up most aggregate dust, will deposit within 100 metres of their source. Intermediate sized particles (between 10 and 30 µm) are likely to travel 200 to 500 metres. Smaller particles (less than 10 µm), which make up the smallest proportion of aggregate dust, can travel up to one kilometre. The farther dust travels from its source, the more its density in the air decreases, thus reducing its impacts.

Table SLM - 10: Typical travel distances for dust by size fraction

Dust Categories	Size µm (micrometers)	Distance Travelled
Large Dust (a)	30 - 75 µm	100 m
Large Dust (b)	10 - 30 µm	200 - 500 m
PM 10	2.5 - 10 µm	1000 m
PM 2.5	< 2.5 µm	> 1000 m

Thomas, 2000.

Dust Impact

The impact of aggregate-related dust on neighbours is generally confined to the level of nuisance, but may create health concerns under some circumstances. The determining factor is the size of the dust particle. The PM_{10} size fraction is the portion of dust that humans cannot filter out through their normal respiratory process and thus can be inhaled.

It is difficult to determine how much PM_{10} and $PM_{2.5}$ dust is actually generated by gravel pits and rock quarries in British Columbia. In well-developed areas, there may be multiple sources of PM_{10} dust generation. As noted above, over ninety percent of aggregate dust is larger than PM_{10} and will likely settle within 100 - 500 metres of its source. Aggregate operations themselves, therefore, are likely to be localized sources of mainly nuisance-sized dust.

Dust Management

Methods For Reducing And Controlling Dust

Dust control may include such measures as:

- site layout and operational practices that minimize the creation and reduce the escape of dust,
- air quality measures that intercept airborne dust, and
- as a last resort, temporary curtailment of dusty activities until adverse weather conditions subside.

Table SLM - 11 outlines these strategies and associated BMPs and measures.

Table SLM - 11: Control options for dust at aggregate sites

Control Strategies	Dust Control Options	BMPs & Measures
SITE LAYOUT **Minimize Creation**	• locate haul-roads, dump sites and stockpiles away and down-wind from neighbours • minimize the height from which material falls • surface roads with dust-free material • lay out and construct stockpiles to minimize dust creation; use gentle slopes and avoid sharp changes of shape • use crushing and screening plants within design capacity, • use conveyors rather than haul-roads • restrict dust generating activities to sheltered areas • create 'sensitive zones' within which dusty activities are limited	• Berm • Drop Height • Tarps • Vegetation Cover • Wind Protection
OPERATIONS **Control Escape**	• limit spillage by not overloading trucks • enclose or provide wind protection for conveyors, chutes, process plant, stockpiles • install a dust removal system (bag system) for the plant • use sprays and mists at dust sources • fit outlets with cyclones, wet-scrubbers and filters • insist on good maintenance and house keeping • compact, grade, surface and maintain haul-roads • fit dust extractors, filters and collectors on drilling rigs • use mats when blasting • use wind-breaks/netting screens/semi-permeable fences • limit drop heights • fit wind-boards/hoods at conveyors/transfer points • reduce speeds and limit movement of vehicles, use upswept exhausts • spray exposed surfaces (haul-roads, dormant faces and stockpiles) with binders • vegetate exposed surfaces, such as overburden stockpiles, with quick growing plants • pave and sweep haul-roads and other high use semi-permanent dusty surfaces • shake dirt off of trucks with rumble bars and provide vehicle washing facilities • provide a surfaced road between vehicle washing facilities and site exit • use closed or sheeted vehicles to carry dry material	• Drop Height • Tarps • Vegetation Cover • Water Spray • Wind Protection • Wheel Washers • hydroseeding • speed limit • dust skirt
AIR QUALITY **Dust Removal**	• use trees or shrubs around the site as coarse air filters • place treed berms near dust generators, receptors or at the perimeter of the site • use sprinklers, sprayers or mist, with or without additives	• Berm • Vegetation Cover • Water Spray
CESSATION	• shut down the operation if, due to unique weather conditions, the extended dispersion of dust cannot be avoided	

Thomas, 2000

Table SLM - 12 highlights the effectiveness of some dust control measures, based on research by the US Environmental Protection Agency.

Table SLM - 12: Efficiency of dust control measures

Activity	Control method	Control efficiency
Loading Stockpile	• reducing drop height	25%
	• telescopic chutes	75%
	• conveyor sprays	75%
Wind Erosion from Stockpile	• regular watering	80%
	• surface crusting agent	up to 99%
	• vegetative wind break	30%
	• lower pile height	30%
Speed Control*	• chemical surface treatment	50%
	• speed control: 30 mph	25%
	• speed control: 20 mph	65%
* from unregulated	• speed control: 15 mph	80%

Thomas, 2000.

Dust Planning Considerations

Dust control planning for an aggregate operation encompasses both the planning of the site layout and the development of operational procedures. Although a Site Layout Map is not normally a permit application requirement, the planning for dust (as well as noise and visual) considerations could be worked out and documented on such a map. A Site Layout Map could contain the following dust components:

- dust generating activities,
- off-site facilities that are sensitive to dust,
- prevailing wind direction(s) and onsite wind patterns,
- placement of berms, stockpiles and tree buffers to create or enhance wind shadows,
- possible locations of dust-generating activities and haul roads in calm locations and far from dust sensitive facilities, and
- location of existing trees and shrubs to create a wind breaks.

Section 3 - Visual Landscape Design

Understanding Visual Landscape Design

Many industrial and commercial facilities in British Columbia have used landscape design techniques to improve the appearance of an operation, thereby gaining greater public acceptance. It has been found that the public's views on an aggregate operation are formed as a result of three factors:

1. Landscape character	"it doesn't fit in"	• how the appearance of the operation contrasts in form, height, mass and colour with the surrounding natural and built landscape (what is visually prominent: topography, soil, vegetation, farming patterns, existing development patterns)
2. Negative associations	"industrial"	• perceived negative associations with industrial operations, dereliction and disturbance
3. Sense of permanence	"ugly forever"	• even though aggregate operations are a temporary land use, they are often perceived as permanent

After Nicholson, 1994.

Visual Impacts: Types and Sources

The visual impacts of sand and gravel pits and quarries are similar from one operation to another. The two main types of visual impacts are:

1. Obstruction	• blocking a pre-existing view, such as with a stockpile
2. Intrusion	• when something new is added that seems out of place, such as a very straight long berm

After Nicholson, 1994.

Table SLM - 13 lists some of the common causes of visual impacts at aggregate operations.

Table SLM - 13: Potential sources of visual impacts at an aggregate site

Potential Source	Visual Landscape Impacts
Quarry/Pit Landforms	• stockpiles • working faces • haul roads, embankments and ramps • settling pond, soil and overburden storage stockpiles • waste heaps - including scrap
Mobile Equipment	• mobile processing equipment • mine haul trucks • transport and pick up trucks - especially at the main access
Building & Structures	• storage hoppers • crushing and screening plant • conveyors • fences
Miscellaneous Sources	• air pollution (e.g., water vapour, dust, vehicle fumes) • dust deposits (e.g., on surrounding vegetation) • mud on roads • lighting - especially during night time operation
Other Sources	• long term alteration to the existing landform profile (e.g., removal of hills and woodlands) • out of place perimeter planting

After Nicholson, 1994.

Managing Visual Landscapes

Visual Landscape Evaluations

In evaluating visual impacts, the degree of significance can often be judged by determining the number of people directly affected. In particular, a "key viewpoint approach" may be worth considering for aggregate operations located close to urban areas. The steps of this approach are outlined in Table SLM - 14.

Table SLM - 14: Overview of key viewpoint visual landscape approach

Steps	Details
Step 1	• identify key viewpoints; e.g., • roads • residential areas • foot paths/parks • tourist facilities
Step 2	• determine the extent of potential visibility (directions and distances) • evaluate sensitivity of viewpoint
Step 3	• determine degree of obstruction or intrusion that will occur • determine the potential changes or the visual impact
Step 4	• modify the mine layout and operations to minimize visual concerns

Reducing Visual Impacts

Reducing the visual impact of an aggregate operation mainly involves simple mine layout planning and does not have to be expensive to be effective. Expenditures made upfront may well pay for themselves down the road in terms of expedient permit applications, planning process and improved community relations.

There are four basic control strategies for reducing the visual impacts of gravel pits and rock quarries: *concentration, interim, concealment* and *innovative* approaches. These control strategies are detailed in Table SLM - 15.

Visual Landscape Planning Considerations

Visual landscape planning for an aggregate operation involves surveying the local landscape, estimating how the operation may affect that landscape, planning the site layout and developing operational procedures to reduce the visual impact. Although not required by the Notice of Work and Reclamation Program, the visual evaluation and planning could be worked out and documented on a Site Layout Map. The assistance of a landscape professional, such as a landscape architect, may expedite the process.

A Site Layout map could contain the following visual landscape design considerations:

- key viewpoints and viewscapes
- visual landscape concerns for the operation, such as industrial structures
- character of local landscape (hilly, flat, woodlots, grassland, sizes and shapes) to determine how the operation may blend into the natural landscape pattern

Table SLM - 15: Suggested control strategies for reducing the visual impact of aggregate operations

Control Strategies	Visual Landscape Control Options	BMPs & Measures
CONCENTRATION	• concentrate as many activities within a given area as possible • move extraction and related activities systematically from one area to the next • re-contour and re-vegetate as you go	• progressive development
INTERIM	• hydro-seed berms and stockpiles (also a theft indicator)	• hydroseeding
CONCEALMENT	Site selection • orient operation to limit visibility of working faces • stagger, offset or curve the quarry access to prevent direct views into the site • ensure sufficient land is available to enable landform modeling, off-site planting and perimeter treatment • consider the topographic position and the potential for natural screening • keep mine elements a similar size and scale to that of the local landscape • design lighting to minimize stray light (light pollution) Method of working • work in a direction away from major sight lines • phase extraction to limit the area of active disturbance • perform progressive reclamation • consider alternative extraction methods • design and locate processing plant to reduce visibility, giving attention to colour, cladding, height of structures, etc. Screening • construct and plant berms • build rock/earth walls rather than fencing • retain existing vegetation wherever possible • consider temporary planting at long term operating sites Camouflage • consider colour and cladding of buildings and plant, within safety margins • limit the height of structures, stockpiles and waste dumps as far as possible and design with shallow gradients Haulage • locate loading facilities to minimize their visibility • route internal haul roads to avoid punctuating the skyline • route external truck routes to avoid sensitive properties and landscapes • screen internal and external routes with berms where necessary Housekeeping • maintain the internal quarry environment - especially where visible externally (e.g., remove scrap and keep stockpile and waste disposal areas tidy) • undertake regular weed control of on and off site planting areas • keep external roads clean and mud-free, including the access and visitor facilities	• Berm • Fences • Lighting Management • Sinking the Plant • boundary planting • entrance layout • painting • progressive reclamation
INNOVATIVE	• site tour to familiarize community with operation's visual elements • construct viewpoints • informative signage	• Signage • tours

After Nicholson, 1994

5-8 RISK MANAGEMENT MODULE - RMM

Sand and gravel pits and rock quarries commonly have activities and equipment that are potentially hazardous. Risks at aggregate operations may affect:

- humans (employees and the public)
- the environment
- the operation

There are many simple steps that can be taken to identify, reduce or even eliminate risks at aggregate operations, including:

- identifying potential risks
- identifying receptors sensitive to risk
- planning site layout to minimize risk exposure
- planning activities and procedures to minimize risk exposure
- planning to communicate risk

This module will define *risk* and discuss areas where risks can be reduced at aggregate operations. Those areas include:

- emergency and spill response
- employee training
- identifying potential environmental issues
- community relations

Risk types that will *not* be discussed in this module include:

- contractual
- political
- investment and general business risks

Section 1 - Risk

Understanding Risk

Risk is a product of the likelihood of a hazard occurring and the consequences that would follow:

RISK = HAZARD X CONSEQUENCE

Risk management is the process taken to reduce the likelihood of a hazardous event from occurring and/or reducing the impact of the consequence. The key terms used in risk management are listed Table RRM - 1.

Table RRM - 1: Key risk terms

risk	the product of the likelihood of a hazardous event and the consequence of that event. Degrees of risk are illustrated in Table RRM - 2
receptor	the affected person, people or environments
hazard	the potential to cause harm; source of dange
consequence	the outcomes of *events*
likelihood	the probability or chance of the *event* occurring
exposure	the susceptibility to loss, perception of risk or the threat; a measure of importance

Figure RMM - 2: The degree of risk is a product of the likelihood of an event times the consequence

Likelihood of Event	Consequence	
	Low	High
Low	*Low risk*	*Moderate risk*
High	*Moderate risk*	*High risk*

Identifying Risk

The first step in risk management is to determine types of risks involved. Table RMM - 3 outlines some of the more common risks associated with aggregate operations, organized by risk category.

Table RMM - 3: Common risk categories and consequences at aggregate operations

RISK CATEGORY	Description	Consequences	BMPs, Modules & Suggestions
HUMAN potential hazards to workers and the general public	• person falls into settling pond and becomes entrapped due to the soft bottom	**Drowning**	• Fences • Signage • design to remove person • public awareness
	• person suffers injury from a fall, interaction with moving equipment or landslide	**Serious Injury**	
	• person suffers fatal injury from a fall or interaction with moving equipment	**Fatality**	
ENVIRONMENTAL potential hazards to physical features, fish, wildlife and ecosystems	• release of silt into the environment from settling pond breach or occurrence of a 200-year storm event	**Fish Habitat Degradation**	• Stormwater & Erosion Control Module • restrict face height
	• release of petroleum products onto the land, particularly in the vicinity of streams	**Water Pollution**	
	• release of a large volume of water into the environment from settling pond breach or occurrence of a 200 year storm event	**Channel Alteration**	
	• release of silt or a large volume of water into the environment from a settling pond breach or occurrence of a 200 year storm event • release of pollutants into the environment in toxic quantities	**Fish Mortality**	
OPERATIONAL potential hazards to the aggregate operation	• previously undisclosed contaminated site/area being put into production	**Contaminated Site**	• Stormwater & Erosion Control Module
	• working face failure	**Landslide**	
	• large volume of water and entrained sediment from a large storm or poor stormwater practices scouring out a gully and causing extensive erosion and deposition	**Debris Flow**	

Risk Management

Once risks are identified at an aggregate operation, their potential to cause harm can be reduced through a number of strategies.

Table RMM - 4: Strategies and options for managing risk at aggregate sites

CONTROL STRATEGIES	EXAMPLES OF RISK CONTROL OPTIONS	BMPs, Modules & Control Options
Remove/ Eliminate Source	• restrict working face height by mining from top down • restrict working face height with benches • re-route natural water courses around the working site • restrict stormwater from saturating the working face area • manage upstream stormwater to prevent channelized debris flows from entering the site from above	• Ditches • Extraction Module • Stormwater & Erosion Control Module
Change mine plan	• re-orient the operation to eliminate risk	• Site Layout Module
Remove from harm's way	• ensure that fencing restricts unauthorized entry to hazardous areas of the site • post proper warning signs • re-route natural water courses around the working site	• Fences • Signage • public awareness

Risk Management Planning

Risk management at an aggregate operation encompasses both the planning for the site layout and the development of operational procedures. The planning and operational procedures should be documented for reference purposes.

Figure RMM - 5: Suggested access-restricting signage

ACTIVE MINING AREA

DO NOT ENTER

Other than an Inspector, only persons
authorized by the Manager shall enter
or be permitted to enter a mine.

HSRC, Part 1.3.1

MINE NAME

Contact Phone Number

Source: Ministry of Energy & Mines

Note: As a minimum standard, these signs should be 60 cm x 40 cm.

Section 2 - Emergency and Spill Response (ESR)

Emergency and Spill Response

All aggregate operations in British Columbia are defined as mines and are therefore required, under the Health, Safety and Reclamation Code 6.13.1(6), to develop, post and regularly update an emergency plan. An emergency plan will help identify and reduce potential risks and help company personnel respond to emergencies and spills in a timely and effective manner, safeguarding people, the environment and the operation.

This section of the Risk Management Module will discuss emergency and spill response options that can be considered for integration into the required emergency plan.

Topics for consideration for ESR planning may include:

- company information
- ESR site map
- marshalling area establishment
- hazard and hazardous material review (WHMIS)
- pollution prevention measures
- summary of roles and responsibilities
- emergency systems and equipment
- emergency response guidelines
- listing of emergency telephone numbers
- emergency response training
- notification and reporting requirements
- containment and clean-up techniques/options

Company Information

Company information may include any corporate information that could be required during an emergency, such as:

- name
- street address, map location
- telephone numbers of trained workers and management
- security guard company name and telephone number
- primary corporate contact names and business, cellular and home phone numbers
- list of trained workers

ESR Site Map

An ESR site map should include all facilities, structures and roads on the site. It may also include potentially hazardous areas, such as fuel storage tanks, refuelling areas, maintenance areas and the designated marshalling area. As equipment and extraction activities move around the site, their locations on the map should be updated as required. This map can be posted at the marshalling area and at other strategic locations around the site. Laminating the map may be useful, as many printers now use water-soluble ink.

Marshalling Area Establishment

Establishing a physical location known to all staff as the marshalling area for emergencies can dramatically decrease emergency response time and help to avoid confusion in a crisis. It can be as simple as a covered location with first aid, fire fighting and spill clean-up supplies and a designated telephone. The marshalling site would also be a good place to post a copy of the ESR site map, information sheets and emergency contact numbers.

Hazard and Hazardous Material Review

One of the key purposes of ESR planning is to identify on-site hazards and hazardous materials. Table RMM-6 identifies typical hazardous materials that may be found at an aggregate operation and Table RMM-7 outlines hazards that may be found at an aggregate operation. Section 2.13 of the Health, Safety and Reclamation Code deals specifically with Workplace Hazardous Material Information Systems (WHMIS).

Table RMM - 6: Example hazardous material identification sheet *

Hazardous Materials	Transportation of Dangerous Goods (TDG) Classification	Typical Quantities	WHMIS Class	Material Safety Data Sheet	Typical Locations
Propane	2.1	• 20,000 litre tank • five 20 kg. bottles	A, B	Yes	• propane station
Diesel	2.2	• 500 litre tank		Yes	• fuelling station
Gasoline	2.4	• 200 litre tank		Yes	• fuelling station
Fuel Oil #1	2.8	• 200 litre tank		Yes	• fuelling station
Lubricants	1.9	• 10 lube cubes		No	• covered storage.
Hydraulic fuel	2.3	• five 170 litre drums		Yes	• covered storage

* The data contained in this table is for demonstration purposes only

Prevention Measures and BMPs

One of the principal objectives of emergency planning is to prevent crises. Many emergencies and spills can be prevented if proper precautions are taken. Two types of prevention are spill prevention (pollution prevention) and emergency prevention. The Ministry of Water, Land and Air Protection (MWLAP) has published two informative booklets relating to these topics: *A Field Guide to Fuel/Handling, Transportation & Storage* (relating to spill prevention) and *Guidelines for Industry Emergency Response Contingency Plans* (relating to emergency prevention). Copies of these booklets can be obtained from local BC Environment offices and are available on the MWLAP Internet sites:
<http://wlapwww.gov.bc.ca/epd/epdpa/industrial_waste/petrochemical/fuel_handling_storage_3rd.pdf> &
<http://wlapwww.gov.bc.ca/epd//epdpa/sw/giercp.html>.

Table RMM - 7: Operational hazards identification sheet

Operational Hazard	Danger	Description
Haul Truck Collision	• personal injury • property damage • environmental damage	• either a single or multiple haul truck incident
Vehicle Incident	• personal injury • property damage	• a motor vehicle accident
Explosion	• personal injury • property damage	• uncontrolled detonation of explosive material
Rock Falls	• personal injury • property damage	• rolling boulders off a working face
Stockpile or Dump Failure	• personal injury • property damage • environmental damage	• failure of stockpile or waste rock dump
Settling Pond Breach	• personal injury • property damage • environmental damage	• breach of settling pond or water management pond dike
Wash Out	• personal injury	• unexpected release of a perched water table within the working face, creating cavities that may collapse
Shallow Surface Instability	• property damage	• minor slumps, rotations and failures at the excavation face
Piping	• personal injury • property damage	• wash out from underground conduits on the working face creating cavities that may collapse
Debris Flow Washout	• property damage • environmental damage • personal injury	• debris flow originating from upstream of the property washing out an excavation face or water retention dike
Fire	• personal injury • property damage • environmental damage	• fire in vehicles, equipment, buildings or vegetation
Overhang/Undercut Banks	• personal injury	• rock that did not completely disengage from the working face after blasting and which may fall without warning
Wedge/Slab Failures	• personal injury	• large sections/blocks of rock defined by joints, bedding, fractures or other discontinuities that dislodge from the face once their downslope side is exposed
Rock Bursts	• personal injury	• rock bursting from a fresh working face from either static or pore pressure forces

Spill Prevention

Spill prevention planning may include such items as those listed in Table RMM - 8.

Table RMM - 8: Sample spill prevention planning check list

	Description	Examples
Material Handling Procedures	• description of the steps that prevent spills from happening	• fuelling procedures • maintenance • training
Containment Structures	• structures that will hold the material in the immediate area or keep it away from where it can cause damage	• fuel tank perimeter dykes 110% • pre-cast concrete block corral • oil/water separators • covered containment with impervious floor and perimeter berms

Emergency Prevention

Emergency prevention planning may include items such are listed in Table RMM - 9.

Table RMM - 9: Sample emergency prevention planning check list

	Description	Examples
Identify Potential Emergencies	• identify possible emergencies at all areas of the operation to determine what can be done to prevent emergency situations	• rock falls • effects of earth quakes • wash out
Develop Operational Procedures	• build structures that will hold the material in the immediate area or keep it away from where it can cause damage	• equipment operational procedures • 110% berms around tanks

For both spills and emergencies, a form similar to Table RMM-10 can be used to identify, record and develop preventative measures.

Table RMM - 10: Sample Emergency and Disaster Identification, Prevention and Protection Form

Emergency and Disaster Identification, Prevention and Protection Form **Objective: Prevention and Protection**
Mine:
Department / Area:
Identify Possible Disaster Situation:
Means of Prevention:
Means of Protection:
Required Action:

British Columbia Ministry of Employment and Investment, 1997, page 7

Summary of Roles and Responsibilities

During an emergency or spill, certain roles need to be performed quickly and with authority. Some roles may be permanently assigned, whereas others will fall upon the first person to arrive at the scene of the incident.

Table RMM - 11: Emergency and Spills Response Plan (ESRP) typical roles and responsibilities

Role/Function	Responsibilities
Designated Emergency or Spills Response Co-ordinator	Ultimately responsible for all activities related to the emergency or spill response, reporting and clean-up. Upon being informed of an emergency or spill, he/she will proceed to the site to confirm the incident and its cause and severity, and initiate response actions in accordance with the ESRP. He/she will authorize all external communication and use of off-site resources, liaise with others involved in the response and ensure clean-up is satisfactory. He/she will ensure that any required follow-up monitoring is conducted, equipment is inspected and that the ESRP is revised as required based on new information.
First Person On-Scene	All employees have the responsibility for emergency and spill detection and reporting. The first person on-scene should assess the situation and, if qualified, start initial containment and response procedures, provided it is safe and feasible to do so. He/she should notify the Emergency or Spills Response Co-ordinator as soon as possible and offer assistance as requested.
Spill Response	A spill response team is mobilized at the direction of the Spills Co-ordinator. The team will carry out spill response practices and procedures and work cooperatively with outside contractors or authorities.
Communications	Responsible for liaison between the specific spill or emergency site and the Emergency or Spills Response Co-ordinator. He/she will provide the relevant information about the spill/emergency to other members of the response team, internal staff and outside authorities, as directed by the Co-ordinator.
Evacuation	Responsible for ensuring that all employees have been evacuated and have assembled in a designated area(s). He/she will count all employees to ensure that all are evacuated, remain orderly and are prepared to assist in the response actions, if necessary.
Fire Fighting	Responsible for ensuring that all fire extinguishers are checked in accordance with Ministry of Energy and Mines regulations and that any fire prevention systems are tested and checked according to insurance and corporate requirements. He/she will co-ordinate all fire fighting activities required on-site.
First Aid	Responsible for the administration of standard first aid to injured employees or the public.
Traffic	Responsible for ensuring that the emergency or spill area is cleared of all unnecessary vehicles and equipment and that access to hydrants, pumping connections and spill response equipment is maintained.
Physical Plant Co-ordination	Responsible for the utility and service shutdown of the physical plant. He/she supervises the shut down of all equipment and processes under the direction of the Emergency or Spills Response Co-ordinator.
Alternates and Assistants	At least one alternate and assistant should be designated for each of these functions.

After: Aggregate Producers Association of Ontario,1999.

Emergency Systems And Equipment

Having the proper equipment on hand to deal with an emergency or disaster can play a large role in mitigating effects. Schedule 2 of the *Mine Emergency Response Plan, Guideline for the Mining Industry*, published by the British Columbia Ministry of Energy and Mines, has an extensive list of emergency systems and equipment. Some of the equipment categories include:

- first aid equipment
- fire fighting equipment
- vehicle rescue equipment
- receding stockpiles/bin equipment
- electrical equipment
- water rescue equipment
- communications equipment
- mine rescue equipment

Specific spill response equipment may include:

- sorbents
- oil recovery pumps
- drum patch kits
- skimmers and booms
- water containers
- Material Safety Data Sheets (MSDS)

Typical locations for emergency systems and equipment could be listed and located on an ESR Site Map.

Many mining jurisdictions also encourage neighbouring operations to cooperate by sharing emergency and spill equipment and supplies. Further, an ESR plan should attempt to work with disaster, fire and/or emergency response plans of local, provincial and federal agencies. For example, operators in areas prone to flooding may decide to provide local emergency officials with gate keys for emergency access to sand and rip rap.

Emergency Response Guidelines

Emergency response guidelines are a company's guide to procedures and plans of action. The guidelines will vary depending upon the size and character of the operation, but will have many similarities.

Generic steps for emergency response are as follows:

1. identify appropriate levels of response
2. decide on plan of action
3. organize emergency operations
4. recognition, notification, initial response (containment), clean-up, and incident documentation

Listing of Emergency Telephone Numbers

Communication is crucial in any emergency. To facilitate communication with outside support and notification agencies, a list of current agencies' telephone numbers and names should be readily available, such as in Table RMM - 12.

Table RMM - 12: Sample emergency telephone and contact information sheet

Agency	Emergency	Non-emergency	Contact Name
Police			
Fire Department			
Ambulance			
Hospital			
Medical Emergency Clinic			
Local Government - Emergency Planning Coordinator			
Local Government - Public Works			
Local Government - Health			
Ministry of Energy and Mines			
Ministry of Water, Air & Land Protection			
MWALP Emg. Response Coord.			
Ministry of Transportation			
Transport Canada			
Environment Canada			
Fisheries and Oceans Canada			
OTHER RESOURCES			
Surface Transport Services			
Air Transport Services			
Spill Response and Clean Up Services			
Site Neighbours			
Other			

Emergency Response Training

Emergency preparedness and employee training at mines in British Columbia is required under part 1.11 of the Health, Safety and Reclamation Code for Mines in British Columbia. For example, in pits where more than 10 people are employed, there must be 4 people trained in mine rescue procedures.

Emergency response will be most effective if all employees are trained to take appropriate and immediate action when they observe an emergency or spill. Companies should support employees to respond confidently and quickly to emergencies and spills and provide incentives to react to and report situations rather than ignore or cover-up. Training must address the "why respond" as well as the "how to respond."

The training may include St. John's First Aid, Industrial First Aid, all relevant legislation and in-house rules and regulations. Each employee should be able to state verbally what his or her duties are in an emergency. For details on training, also refer to Section 3 of this module, Employee Training.

Notification and Reporting Requirements

The Health, Safety and Reclamation Code for Mines in British Columbia requires the reporting of all dangerous occurrences at mine sites, including aggregate operations. Refer to Section 1.7.3 for a complete description of dangerous occurrences.

Other government regulatory agencies will require notification of spills as defined in their statutes. All notification should be factual and timely to avoid potential prosecution. Any information provided to regulatory agencies during notification of an incident can be used as evidence in any future litigation or prosecution. Refer to the Ministry of Water, Land and Air Protection (MWLAP) document *A Field Guide to Fuel/Handling, Transportation & Storage* for reporting guidelines and requirements on spilled hydrocarbons. Refer specifically to Section 9, "Spill Response" for a summary of the potential legal ramifications of a spill and of the failure to report it.
Reporting spills include discharge from tanker trucks, chemical fires and releases of pollutants to the environment that result in non-compliance with the *Waste Management Act*.

Figure RMM - 13: Sample MWLAP spill report form

SPILL REPORT FORM

Pursuant to the Spill Reporting Regulation of the *Waste Management Act*

All non-authorized releases or discharges of contaminants to the environment must be reported immediately to the Provincial Emergency Program: **1-800-663-3456**.

Particulars of Spill Report:

(a) Name of reporter: ______________________________
Telephone: ______________________________
(b) Name of company causing spill: ______________________________
Telephone: ______________________________
(c) Location of spill: ______________________________
(d) Date/time of spill: ______________________________
(e) Substance spilled: ______________________________
Quantity: ______________________________
(f) Cause and effect of spill: ______________________________
(g) Measures taken to stop/contain/minimize spill: ______________________________
(h) Description of spill location and surrounding area: ______________________________
(i) Further action required: ______________________________
(j) Agencies on site: ______________________________
(k) Others notified of spill: ______________________________
Dated: ______________________________
REPORT COMPLETED BY: ______________________________

From: *Summary of Environmental Standards & Guidelines for Fuel Handling, Transportation and Storage*

Containment and Clean-up Techniques/Options

The ESR plan may also provide information on techniques for handling containment and clean up. The following tables are examples of such information.

Table RMM - 14: Guide to selecting containment techniques for spills on water

Technique	Primary Use	Resources Required
Containment Boom	• best at location where spill enters water	• booms totalling 1.5 to 2 times slick diameter • recovery device such as a skimmer
Sorbent Boom	• best across small ditches	• disposal containers or incinerator for used sorbents • chicken wire and supports to make "fence" • earth moving or digging equipment • operators, foreman, labourers
Earth Berm	• best across shallow ditches	• boom and recovery device such as a skimmer • may also require sandbags, liner material, sheets of metal or wood • a 10 x 4 x 2 m berm requires one hour to build

After: Aggregate Producers Association of Ontario, 1999, page D-8.

Table RMM - 15: Guide to selecting containment techniques for spills on land

Technique	Primary Use	Controlling Variables	Resources Required
Earth Dike	• best suited for spills on relatively flat areas	• sufficient earth may not be available depending on location and season • crew of four can create 5 m of dike per hour	• earth moving machine (e.g., bulldozer) or digging equipment (e.g., backhoe) • sandbags, liner material, sand or gravel • labour
Sorbent Dike	• can provide temporary containment and clean-up • applicable in all seasons	• requires sufficient sorbent material • may become impractical for large spill volumes	• sorbent material • temporary storage or a facility to burn used sorbents
Snow/ Ice Dike	• best suited for spills on relatively flat areas in winter	• requires sufficient snow or ice • only applicable when ice is sufficiently thick (greater than 1 m) • a crew of four with a bulldozer can create 10 m of dike per hour	• earth moving machine (e.g., bulldozer) • ice chain saws • equipment to spray water onto snow • labour
Land Trench	• best on relatively flat areas	• during the winter, frozen earth may be too difficult to excavate • in some areas, soil may be too thin to create trench • can produce 30 m per hour per machine in summer, half that in winter	• earth digging equipment (such as a backhoe or shovels) • operators, labourers, foreman • an oil recovery unit (pump)

After: Aggregate Producers Association of Ontario, 1999, page D-8.

Table RMM - 16: Guide to selecting cleanup techniques for spills on land

Technique	Controlling Variables	Environmental Effects	Resources Required
Excavation by Bulldozer	• heavy equipment site access • facility to receive excavated material • difficult in frozen soil	• removes 10 to 25 cm of surface material • can lead to erosion or surface instability • removes all shallow biota/vegetation • vegetation is slow to recover	• bulldozer, fuel and operator • work crew and foreman • method to handle or dispose of excavated material
Excavation by Front-End Loader	• heavy/light equipment site access • facility to receive excavated material • difficult in frozen soil	• as above, but excavation may be to depth of 50 cm • vegetation is slow to recover	• loader, fuel and operator • work crew and foreman • method to handle or dispose of excavated material
Excavation by Backhoe	• heavy/light equipment site access • facility to receive excavated material • difficult in frozen soil	• as above but excavation may be to depth of 50 cm	• backhoe, fuel and operator • work crew and foreman • methods to handle or dispose of excavated material
High-pressure Flushing	• light equipment site access • water supply • not applicable in winter	• disturbs surface of soil • removes some organisms	• pressurized equipment • downslope containment and recovery facilities • water supply • work crew
Low-pressure Flushing	• light equipment site access; water supply • not applicable in winter	• as above but to a lesser degree	• as above
Steam Cleaning	• light equipment site access • water supply • not applicable in winter	• heat will damage surface vegetation and shallow organisms	• as above
Sandblasting	• light equipment site access • adequate supply of sand • impractical for most sites	• adds material to the environment • potential recontamination, erosion or deeper penetration into soil • destroys surface vegetation and shallow organisms	• pressurized equipment • downslope containment and recovery facilities • supply of sand • work crew
Pumping	• nearby storage • heavy equipment access if vacuum truck is used	• surface disturbance if sump is excavated	• pump or vacuum truck and operator • storage facility
Manual Removal	• labour intensive and time consuming • best suited for areas lightly contaminated or where equipment access is unavailable	• removes up to 5 cm of soil • some surface disturbance and removal of shallow organisms and vegetation • more rapid repopulation of organisms than other excavation techniques	• work crew with hand tools (e.g., rakes, shovels, wheelbarrows) • disposal facilities
Manual Scraping	• labour intensive and time consuming • best suited for man-made structures or contaminated rocks and boulders	• surface disturbance • removes, crushes surface vegetation and organisms	• work crew with hand tools • downslope containment facilities • disposal facilities
Sorbent Application	• adequate supply of sorbents	• relatively little damage except surface disturbance of foot traffic	• sorbents • work crew • disposal facility for used sorbent

After: Aggregate Producers Association of Ontario, 1999, page D-9.

Section 3 - Employee Training

All aggregate operations have inherent operational, safety and environmental risks and concerns. An established training plan can help ensure that critical knowledge is available to both new and experiences employees. A training plan can also provide a structure for performance evaluation, specific task training and refresher training.

Historically, training development costs have deterred many smaller operations from implementing training programs. Recently, many training courses have become available at reduced fees, or in some cases, for no fee at all. Thus now the largest cost associated with training is employee time. Operators are advised to contact their industry association for advice on training options.

General Training Considerations

Basic Training Program

Planning for employee training should define the knowledge and skills required for the various tasks that are performed at the operation, with emphasis on safety, health and environmental issues. The Health, Safety and Reclamation Code for Mines in British Columbia states that the mine manager shall ensure that workers are adequately trained to do their job or are working under the guidance of someone who has competency both in the job and in giving instructions.

Employee training planning should also identify:

- how employees will receive training,
- whether there will be written material,
- whether the employees receive verbal instructions or view videos,
- when new employees will receive training,
- when existing employees will receive refresher courses, and
- whether employee training will include an assessment of training effectiveness.

Compliance with Permit Conditions

Permit compliance depends directly on the competence of the employees who operate the loaders, crushers and haul trucks that transform the raw material into finished product. The mine manager is required to establish and maintain, to the satisfaction of the Chief Inspector of Mines, training programs for those employees and should ensure that:

1) all employees receive thorough orientation and basic instruction in safe work practices,
2) workers have been suitably trained and certified, if required, to safely perform any work to which they are assigned, and
3) workers know the permit conditions that apply to their work.

Best Management Practices

BMPs are designed to be cost effective, ensure heath and safety, protect the environment and help operations meet permit conditions. The BMP infosheets in Chapter 7 of this Handbook can be used as training tools, as well as operational tools and guidelines. Planning for training should identify all BMPs used at the site, designate which employees have responsibility for each BMP and list maintenance requirements for continued effectiveness of BMPs.

Training Guidelines

The Health, Safety and Reclamation Code for Mines in British Columbia suggests that training programs should be implemented before a new aggregate mine begins operations. An example for identifying employee training is provided in Tables RMM-17 and RMM-18.

Table RMM - 17: Suggestions for identifying aggregate operation employee training needs

Employee/Task Identifier	Training Suggestions
New Miner	• safety orientation • job-specific subjects - prior to starting work • primary task training - should ensure a good understanding of what is specifically required • first aid and WHMIS training
Newly Hired Experienced Miner	• safety orientation • general review to ensure job-specific knowledge is current • review of certificates for validity and expiry dates
New Task Training	• specific task training - whenever a miner is assigned to a new task • training times - will vary for each task and should be included in the mine's training plan
Site Specific Hazard Awareness Training	• will vary depending on the worker's exposure to hazards • should consider the presence of non-miners on the mine site

There are other federal and provincial industrial training and certification requirements that may apply to aggregate operations. These include:

- WHMIS
- Supervision
- Industrial First Aid
- Blasting
- Driver Training
- Fire Fighting

Written records should be kept on file for all training, so that duplicate training does not occur and as proof of permit compliance.

Table RMM - 18: Sample "training needs" evaluation form

	General			**Certificates Required**					**Equipment**					**Hazardous Site**				**Permit Conditions**			
Expiry date	08/02			04/01	03/02	06/04	03/02	01/03	04/02	12/01	02/02			03/02	10/01			04/04			
Employee	Fire Fighting			Blasting	First Aid 1	First Aid 2	WHMIS	Mine Rescue	Loader	Haul Truck	Crusher			Dangerous Slopes	Fuelling			Stormwater			
Sam Sand	✓			✓	✓		✓		✓					✓	✓						
Cam Clay	✓				✓		✓		✓		✓			✓	✓			✓			
Ginny Grit					✓	✓	✓			✓	✓				✓			✓			
Rob Rock	✓			✓	✓	✓	✓			✓					✓						

Section 4 - Identifying Potential Environmental Risks

To reduce risks of harm to the environment during development, local environmental features should be considered during the planning phase. Potential local issues would include the presence of rare ecosystems, wildlife trees, and "red" or "blue" listed animals or fish. This section of the Risk Management Module will assist aggregate operators in making these determinations during the planning, operation and reclamation of an aggregate site.

After reviewing information sources, consultation with the agency responsible for a potentially sensitive environmental feature should be sought. Accounting for these features early in the mine development planning stage reduces potential environmental risks and may make the project more viable or at least decrease the resources necessary to account for the sensitive feature once operations begin.

What Are Identified Environmental Features

Identified environmental features are any endangered plants, fish, birds, mammals, trees, ecosystems or wildlife that have been documented by scientific authorities. The main source for this type of information is the British Columbia Conservation Data Centre (CDC), which collects and disseminates information on many rare and endangered plants, animals and plant communities in British Columbia. In addition, some local governments have Environmentally Sensitive Areas Atlases, which identify local features such as streams, wetlands, coastlines, areas of rare vegetation, older forests, riparian vegetation and woodlands.

The CDC information is compiled and maintained in a computerized database that provides a centralized source of information on the status, locations and level of protection for these rare organisms and ecosystems. The CDC is part of the Conservation Biology Section of the Resources Inventory Branch, in the Ministry of Sustainable Resource Management.

A Natural Features Map for the operation and surrounding area is a good place to start recording potential environmental risks for an aggregate operation. This map could be a paper copy of one of the Federal 1:50,000 National Topographic System (NTS) maps or the newer 1:20,000 Provincial Terrain Resource Information Management (TRIM) maps. Information for ordering TRIM maps is provided in Table RMM - 19.

Table RMM - 19: Sources for ordering TRIM maps

• Map Dealer	List of Local Agents
• Government Agents	http://home.gdbc.gov.bc.ca/catalog/govt_agent.htm
• TRIM Hardcopy Map Agents	http://home.gdbc.gov.bc.ca/catalog/gdbc_map.htm
• Nanaimo Maps	1-800-665-2513
or Ordered Over the Internet:	
• Geographic Data British Columbia	http://home.gdbc.gov.bc.ca/

These maps show streams and wetlands, key areas for wildlife. The fact that a stream does not flow all year does not discount it from being habitat for various species. Numerous agencies such as Fisheries and Oceans Canada or provincial environment officials will be able to give advice on fish habitat.

Table RMM - 20: Examples of environmental features and primary contact agencies

Environmental Feature	Example	Responsible Agency(s)	Internet Address
Red-Listed Species	Pacific Giant Salamander	**B.C. Conservation Data Centre** MSRM	http://srmwww.gov.bc.ca/cdc/trackinglists/species_lists.htm
Blue-Listed Species	Townsend's Big-eared Bat	**B.C. Conservation Data Centre** MSRM	http://srmwww.gov.bc.ca/cdc/trackinglists/species_lists.htm
Fisheries Habitat	Fish-bearing streams and stream-side habitat	**Fisheries and Oceans Canada** or MWLAP	Contact local DFO or MWLAP office
Record-Sized Trees	British Columbia Register of Big Trees	**B.C. Conservation Data Centre** or MSRM	http://srmwww.gov.bc.ca/cdc/trees.htm
Rare Ecosystems	Garry Oak/Ocean Spray	**B.C. Conservation Data Centre** MSRM	http://srmwww.gov.bc.ca/cdc/sei/index.htm
Groundwater Aquifers		**Groundwater Section,** Water Management Branch Water, Land and Air Protection	http://wlapwww.gov.bc.ca/wat/gws/gwis.html
Water wells		**Groundwater Section,** Water Management Branch Water, Land and Air Protection	http://wlapwww.gov.bc.ca/wat/gws/gwis.html
Community Watersheds		**Community Watersheds Section,** Ecosystem Management Unit, Habitat Branch, Watershed Planner Water, Land and Air Protection	http://srmwww.gov.bc.ca/wat/cws/cwshome.htm
Rare Occurrences	Cascade Mantled Ground Squirrel	**B.C. Conservation Data Centre** MSRM	http://srmwww.gov.bc.ca/cdc/index.htm

How to Find Out if There are Identified Environmental Features

It is up to the proponent to identify an environmental feature or demonstrate an effort to identify an environmental feature. Not knowing about a legally protected environmental feature is not an argument for failing to protect that feature.

Table RMM - 20 provides the lead agencies responsible for tracking environmental features and some direct Internet addresses. Table RMM - 21 provides more detail and contact information.

Table RMM - 21: Contact agencies for possible environmental features

Contact Agencies	
Enquiry BC	Vancouver 660-2421; Victoria 387-6121 Elsewhere in B.C. 1 800 663-7867
BC Connects	http://www.bcconnects.gov.bc.ca/
Ministry of Energy & Mines Regional Offices	see Enquiry BC http://www.gov.bc.ca/em/
Ministry of Water, Land and Air Protection Regional Offices	see Enquiry BC http://wlapwww.gov.bc.ca/main/prgs/regions.htm
Ministry of Forests Regional Offices	see Enquiry BC http://www.for.gov.bc.ca/mof/regdis.htm
B.C. Conservation Data Centre, MSRM	(250) 356-0928 http://srmwww.gov.bc.ca/cdc/index.htm
Fisheries and Oceans Canada	1 800 "O-Canada" or 1 800 662-6232 http://www.dfo-mpo.gc.ca/index.htm
Local Governments	Refer to Blue pages of phone book for locations and numbers.

Section 5 - Community Relations

Community interest in local aggregate operations is increasing, in part due to increased urban densities, downloading of provincial government responsibilities to local governments and the establishment of official community plans. Accompanying this interest is an increased expectation for aggregate mines to operate within limited noise and dust levels, regulated hours of operation and visual landscape restrictions.

Much of this handbook is designed to help operators reduce safety and environmental risks and meet public expectations regarding compatibility with adjacent land uses. Aggregate operators may gain a better understanding of community expectations, and communities may gain a better understanding of aggregate operations, if the operators take an active role in their communities.

Community relation activities that have been successfully used by aggregate operators in British Columbia include:

- community open houses
- school visits
- community liaison committees
- participation in community activities

Direct guidance on establishing a community relation plan may be best obtained from industry associations and various trade publications.

5-9 BMP Monitoring Module - BMM

Who Needs a BMP Monitoring Plan

Best Management Practices (BMPs) require skillful installation, application and maintenance to be effective. Once implemented, they require monitoring to ensure that they are achieving the objectives for which they were selected.

Using BMPs does not exonerate an operator from permit requirements or from complying with other legal requirements. The BMPs described in this handbook are intended to assist in meeting or exceeding permit requirements and controlling social and environmental impacts. Monitoring the success of BMPs, whether they are structures like a check dam or procedures like limiting drop height, will help assure compliance with legal requirements.

What is BMP Monitoring

Monitoring BMPs typically involves inspecting the results or performance of the practice. To illustrate, a bent nail will quickly tell you if a hammer is not working properly, whether the alignment was off, the sizing of the hammer was incorrect or a knot was hit. Monitoring can assist with focusing alignment and sizing and accounting for the unknown so that the next nail goes in straight.

BMP monitoring also involves scheduling of inspections to ensure that the outcomes of BMPs meet expectations. At the heart of BMP effectiveness monitoring is a listing of each BMP, its expected performance and an assessment of whether the controlled value (noise, dust, water quality, etc.) is within targeted limits. Table BMM - 3 provides an example of how to organize that information and can be adapted by operators to meet their specific needs. Table BMM - 3 groups BMPs by control categories, such as "Dust Control", but operators should feel free to group BMPs by any other category (see Table BMM-1 for suitable examples).

Table BMM - 1: Sample inspection category options for BMP monitoring

Inspection Category	Examples
Frequency	• daily • weekly • monthly • bi-annual
Area	• stockpiling area • extraction area • processing area • reclaimed area
Event	• when production volume threshold reached • after a large storm • dry conditions (according to local forestry district fire hazard rating) • air quality event (perhaps as published in local news paper)

Collecting the Information

Monitoring involves collecting and assessing information. Some factors to consider in determining how to best do that include:

1. **Find a Method that Works for the Operation:**

   What works for one operation may not work for another of a different size, location or product line. Companies also have a culture or "way of doing what they do". Collect BMP effectiveness information in a way that works for the operation.

2. **Fit Monitoring to the Monitor:**

   The type of person inspecting the BMPs will determine how foolproof the monitoring form or schedule should be. An employee who has never seen a check dam before should be asked much more explicit questions than someone with technical training. The technically trained may be simply asked, "Is it O.K?" while the untrained should be asked questions like, "Are there signs of erosion of the soil by water or is sediment collecting within 30 cm of the top of the check dam?"

3. **Type of Information Required:**

   For information that doesn't require a number or value, such as simple binary data (e.g., whether traffic speed is generating dust), subjective monitoring could be done by most competent employees. For information such as turbidity of discharge, specific instructions, equipment or training may be required for effective monitoring.

The information can be recorded free-form in a notebook, binder or clipboard or on prepared forms. On a prepared form, information queries can be asked in a number of ways. See Table BMM - 2 for illustration.

Table BMM - 2: Options for collecting monitoring information on dust plumes from traffic

Query Style	Example: Speed Reduction to limit dust created by haul trucks.
Free form	________________________ (blank note book)
Fill in the blanks	Dust plumes __(describe any dust plumes)__
Yes/No questions	Dust plumes: yes/no
Check boxes	Dust Plumes: ☐ Large Plume (greater than the size of the truck) ☐ Moderate Plume (same size as the truck) ☐ Small Plume (smaller than half the size of the truck) ☐ No Plume (smaller than half height of the tires)
Data	HiVol. Sample results Dust Fall Sample results

Table BMM - 3: Sample BMP effectiveness monitoring tracking sheet

ABC GRAVEL Weekly BMP Monitoring Report

No.:

Inspector

Date:

BMP	I.D.	Location (s)	Control Objectives	Maintenance required	Failure indicators	Met Control Target	Notes
				ref. BMP 4 Schedule			
Stormwater Control							
Checkdam	CD01	Ditch # 8	• to control flows • prevent erosion • trap sediment	ß clean out ß depth of sediment ___ cm.	ß erosion around top ß erosion in ditch line ß downstream scour pool ß	**Stormwater** ß turbidity, ß TSS	ß
Checkdam	CD02	Ditch # 4	• to control flows • prevent erosion • trap sediment	ß clean out ß depth of sediment ___ cm.	ß erosion around top ß erosion in ditch line ß downstream scour pool ß	**Stormwater** ß turbidity, ß TSS	ß
Settling Pond	SP01	End Ditch #8	• decant storm water	ß clean out ß depth of sediment ___ cm.	ß piping ß use of overflow	**Stormwater** ß turbidity, ß TSS	ß
Dust Controls							
Drop Height	DH01	Face Loader Operations	• reduce dust	n/a	ß dust complaints ß dusty perimeter trees	**Air quality** ß air quality	ß
Drop Height	DH02	Trucks into Crusher #1	• reduce dust	n/a	ß dust complaints ß dusty perimeter trees	**Air quality** ß air quality	ß
Telescoping Chute	TC01	Stockpile Conveyor	• reduce dust	ß check for rips	ß dust complaints ß dusty perimeter trees	**Air quality** ß air quality	ß
Perimeter Trees		Perimeter	• intercept dust	ß clean	ß dust complaints	**Air quality** ß air quality	ß

When to Monitor

Schedules for BMP effectiveness monitoring will be determined by the nature of the BMP itself and by the consequences of failure. Treed berms, for example, would not have the same inspection schedule as settling ponds. Certain BMPs have only a seasonal significance or are tasks performed only one or two days a year. Monitoring of stormwater BMP's, for example, should be intensive for the 18 hours it takes for a 200-year storm to blow through, but could be reduced during the dry season. Thus, a practical solution would be to have a regular schedule, such as monthly in the dry season and weekly in the wet season, but with the ability to add extra monitoring in response to identified events, such as peak flows during major storms.

Monitoring can generally be completed during the facility's normal working hours and while processing is at normal levels, noting certain exceptions as illustrated above.

Setting up a Monitoring Program

Table BMM - 4 lists some key steps in establishing a BMP effectiveness monitoring program.

Table BMM - 4: Key steps to establishing a BMP effectiveness monitoring program

Steps	Step Details
1. Set Up	• list and identify location of BMPs • list activities & site features • create monitoring map to assist in planning and organizing BMP monitoring • identify parameters to be monitored • establish a standard procedure or routine • train the persons monitoring
2. Monitor	• begin BMP effectiveness monitoring schedule • evaluate monitoring
3. Make Changes	• make changes to BMPs or select other BMPs where goals are not met • make changes to monitoring program if it is not providing useful information

Chapter 6

Reclamation

The focus of this handbook is on the planning and operation of sand and gravel pits and rock quarries. A survey of relevant documents, conducted before the writing of this handbook, indicated that numerous aggregate operation reclamation handbooks are currently available and that further reclamation advice is not needed.

The key reclamation advice that this handbook provides is:

- **Extraction is a Temporary Activity** - As temporary occupiers of the land, aggregate operations should conduct their business in such a manner as to not limit post-extraction land uses. Sites where no development will occur should be returned to their natural state with an equal or enhanced ability to grow trees or other forms of vegetation. For development areas, community and environmental stewardship should be included in the planning and operational stages of the pit or quarry.

- **Know the End Land Use** - In some circumstances, a specific end land use can be determined and may be defined during the permitting process. For operations that have a life span of more than twenty years, general assumptions can be made to help address uncertainty. If local government has zoned the property, that zoning may define the range of permitted post-mining activities.

- **Plan For Reclamation -** Whatever the level of certainty regarding end land use, an operator should plan for reclamation. This planning can reduce costs by decreasing double handling and the need for material storage areas. Furthermore, early re-vegetation of post-extraction areas reduces dust, visual impacts and stormwater concerns.

- **Account for Grade** - A flat uniform deposit on level ground may be reclaimed by any number of strategies, whereas a steep mixed grade hillside deposit will have limited reclamation options. Even if a form of progressive reclamation is possible, it may be years until sufficient working space has been developed to allow reclamation to begin.

Reclamation Strategies

The choice between reclamation strategies may be dependent upon:

- the scale of the operation
- the geometry of the deposit
- the surface geometry
- the grade distribution of the deposit

Four general strategies can be used for the timing of final reclamation. These are listed in Table R - 1.

Table R - 1: General reclamation strategies

Reclamation Strategy	Notes
Post-extraction Reclamation	• reclamation initiated only after all extraction stops
Interim Reclamation	• temporary reclamation during operation to stabilize disturbed areas
Concurrent Reclamation - *(Progressive* or *Continuous)*	• on-going reclamation as aggregate resources are removed • overburden and soil is immediately replaced
Segmented Reclamation	• reclamation after extraction has stopped in one area of the pit or quarry

After: Norman and others (1997).

For advice on reclamation, please refer to:

Price, B., Editor (1995): **Reclamation and Environmental Protection Handbook for Sand, Gravel and Quarry Operations in British Columbia.** *British Columbia Ministry of Energy, Mines and Petroleum Resources; Ministry of Transportation and Highways and Natural Resources Canada.*

Chapter 7

Best Management Practices

Introduction

This chapter of the handbook presents thirty-seven Best Management Practices (BMPs). The BMPs have been selected for specific application in aggregate operations. There are, however, many "general reference" BMPs that can also be useful. Three recommended websites are:

1. *Water Related BMP's in the Landscape.* Watershed Science Institute. URL <http://www.abe.msstate.edu/csd/NRCS-BMPs/>, October 2001

2. *Best Management Practices for Reclaiming Surface Mines in Washington and Oregon.* URL <http://www.wa.gov/dnr/htdocs/ger/pdf/bmp.pdf> [PDF, 7.6 Mb], June 2001, and

3. *Stormwater Management Manual for Western Washington*, Volumes I-5 Washington State Department of Ecology, URL <http://www.ecy.wa.gov/biblio/9911.html>, June 2001 (scroll to the bottom of the page for links to volume 2-5).

Also see the "Additional BMP Websites" section at the end of this introduction.

How to Choose BMPs

There are three ways to select a BMP from this handbook:

1. Refer to Table 7-1 and 7-2 BMP Module Reference Charts.

In these charts, BMPs are cross-referenced against Module topics (extraction, traffic, etc.). Table 7-1 organizes the BMP's into five thematic groupings (Stormwater Mangagement, Erosion Control, Noise and Dust, Risk Management and Pollution Prevention), while Table 7-2 lists them alphabetically.

2. Review Topical Modules for Suggestions

Tables within the Chapter 5 modules suggest specific BMPs to address specific problems.

3. Flip Through the BMPs in Chapter 7

The BMPs in Chapter 7 all have a "USE" box in the upper right hand corner of the first page. They can be selected by simply looking for a "USE" box with an appropriate application.

Additional BMP Websites

British Columbia Ministry of Water, Land and Air Protection. (2001): **Environmental Objectives, Best Management Practices and Requirements for Land Developments.** BC Environment, Vancouver Island Region, URL <http://wlapwww.gov.bc.ca/vir/pa/bmp_dev1.htm>, October 2001.

British Columbia Ministry of Water, Land and Air Protection. (2001): **Best Management Practices To Protect Water Quality.** Water Quality Branch, URL < http://wlapwww.gov.bc.ca/wat/wq/NPS_web_page/BMP_Compendium/BMP_Introduction/BMP_Home.htm >, October 2001.

Chilibeck, B., Chislett, G. and Norris, G. (1992): **Land Development Guidelines for the Protection of Aquatic Habitat**; *Department of Fisheries and Oceans*, and *Ministry of Environment, Lands and Parks*, URL <http://www-heb.pac.dfo-mpo.gc.ca/english/publications/PDF/guidelines/ldg.PDF> [PDF, 1.5 Mb], June 2001.

Ciuba, S. and Austin, L. (2001): **Runoff Treatment BMPs**; *in* Stormwater Management Manual for Western Washington, Volume V; *Washington State Department of Ecology*, Publication 9915, URL <http://www.ecy.wa.gov/biblio/9915.html>, June 2001.

Cole, L., Smith, P., Wright, J. and Clough, R. (1999): **Controlling the Environmental Effects of Recycled and Secondary Production Good Practice Guidance**; *United Kingdom Department of the Environment, Transportation and the Regions*, URL <http://www.planning.detr.gov.uk/recycled/practice/index.htm>, June 2001.

Coulter, T.S. and Halladay, D.R. (1997): **Manual of Control of Erosion and Shallow Slope Movement**; *Ministry of Transportation and Highways*, Vancouver Island Highway Project.

Field, L.Y. and Engel, B.A. **Best Management Practices for Soil Erosion**; *Purdue University*, Agricultural and Biological Engineering Department, URL <http://pasture.ecn.purdue.edu/AGEN521/epadir/erosion/asm521.html>, October 2001.

Norman, D.K., Wampler, P.J., Throop, A.H., Schnitzer, E.F. and Roloff, J.M. (1997): **Best Management Practices for Reclaiming Surface Mines in Washington and Oregon**; *Washington State Department of Natural Resources* Open File Report 96-2 and *Oregon Department of Geology and Mineral Industries* Open File Report O-96-2, 128 pages, URL <http://www.wa.gov/dnr/htdocs/ger/pdf/bmp.pdf> [PDF, 7.6 Mb], June 2001.

O'Brien, E. (2001): **Minimum Technical Requirements**; Stormwater Management Manual for Western Washington, Volume I. *Washington State Department of Ecology*, Publication 9911, URL <http://www.ecy.wa.gov/biblio/9911.html>, June 2001.

Thomas, M., Editor (2000): **Controlling and Mitigating the Environmental Effects of Minerals Extraction in England Consultation Paper**; Mineral Planning Guidance Note 11. *United Kingdom Department of the Environment, Transportation and the Regions*, URL <http://www.planning.detr.gov.uk/consult/mpg11/index.htm>, June 2001.

United States Department of Agriculture and Mississippi State University. (1999): **Water Related BMP's in the Landscape**; *Watershed Science Institute*. Created for the *Natural Resource Conservation Service, United States Department of Agriculture* by the *Center for Sustainable*

Design Mississippi State University Departments of Landscape Architecture, Agricultural and Biological Engineering, and the *College of Agriculture and Life Sciences*, URL <http://www.abe.msstate.edu/scd/NRSC-BMPs/index.html>, October 2001.

Appendix 1 - AGGREGATE GEOLOGY

Note: definitions are specific to aggregate operations or are operational definitions used in the aggregate industry.

aggregate	Sand, gravel, crushed stone and quarried rock used for construction purposes.
ambient water quality	Water in its natural state; the existing environmental condition of the water or how it was found.
aquifer	A layer of gravel, sand or porous, fractured rock containing saturated permeable material through which significant amounts of ground water can travel to wells and springs.
as-built drawings	Engineering plans that have been revised to reflect all changes to the plans that occurred during construction.
as-graded	The configuration of the surface conditions on completion of grading.
average monthly discharge	The average of the measured turbidity or other water quality values (TSS, TDS, etc.) collected from a discharge point over a calendar month's time. For further water quality information related to the environment, contact the local office of the Ministry of Water, Land and Air Protection. For information related to discharge and drinking water, contact the local office of the Regional Health Authority.
baffles	Partitions within a settling pond or retention basin designed to increase the length the water travels before discharge.
bedrock	The solid rock that underlies the soil, overburden and unconsolidated material.
bench	A relatively level or back sloping step, excavated or constructed on the face of a graded slope surface for safety, stability, drainage and to facilitate maintenance.
berm	A constructed barrier of overburden, topsoil or waste rock, often planted with trees, shrubs and ground cover. Berms are used to block noise, dust and views of an aggregate operation from reaching adjacent properties.
best management practices (BMP)	BMPs can be physical structures, activities, practices or procedures that prevent, reduce or mitigate an undesired event, impact or effect.
biodiversity	The variety and variability among living organisms and the ecological complexes in which they occur.
bioengineering	Restoration or reinforcement of slopes and stream banks with living plant materials.
biophysics	The study of the biological and physical characteristics of an area (e.g., topography, soils, climate, landforms, watercourses, vegetation, etc.).
blue-listed species	Vulnerable indigenous species or sub species (refer to *endangered species*).
borrow pit	An excavation to provide fill for construction activities.
buffer strip	A strip of land that separates incompatible activities. Buffer strips can be used to intercept dust and noise, enhance aesthetics or other qualities along or adjacent to residences, roads and trails, filter stormwater runoff or protect an environmentally sensitive area such as a stream (riparian area). They may be land left in its natural state or planted to perform specific objectives.
clearing	The removal of trees and shrubs.
coir fascines	Although "coir" is actually made from coconut husks, this term has been adopted in BC to mean a mat or bundle made from willow whips, branches or cuttings for such uses as filling ditches or making revetments on unstable slopes or banks.

competency	A measure of the strength or soundness of rock.
community values	Consensus, expectations and opinions of a local population.
crushed stone	Rock, boulders and cobbles that are blasted or mined and subsequently crushed and processed into aggregate.
deleterious	Harmful to health or well-being.
deposit characteristics	Physical properties, sedimentary features, quality, particle gradation and composition of a deposit.
deposit model	A planning model that includes the geological feature that makes up the sand and gravel (e.g., Delta, alluvial terrace, outwash plain, drumlin), the deposit characteristic (e.g., rock types, rock characteristics), the deposit size (e.g., surface area, depth) and environmental effects of mining (e.g., high clay content).
deposit size	Surface area, thickness and volume of gravel.
ditch grade control	The action of controlling the steepness of a channel, ditch or any watercourse. Grades of less than 5 percent are generally desirable for watercourses to avoid erosion. Check Dams are commonly used to control grades in ditches.
effluent	Waste material released either into the air or water, or onto land.
endangered species	Species and ecosystems at risk in British Columbia number in the hundreds. The identified species and ecosystems are tracked and ranked by the BC Conservation Data Centre (CDC). The ranking assists the Ministry of Sustainable Resource Management in assigning them a red or blue listed status. The red listing means that the listed species are, or are close to being extirpated, endangered or threatened. Extirpated means they no longer exist in the wild in B.C., but do occur elsewhere. Endangered means they are facing imminent extirpation or extinction. Threatened means that they are likely to become endangered if limiting factors are not reversed. The blue list includes vulnerable indigenous species or subspecies that are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. It also includes species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category.
erosion	The wearing away of the ground surface as the result of wind, running water, ice or other geological agents, including such processes as gravitational creep.
erosion and sediment control	Procedures intended to prevent erosion and sedimentation, such as preserving natural vegetation, seeding, mulching and matting, plastic covering, filter fences, and sediment traps and ponds.
extraction	The process of removing raw material, rock or aggregate from the deposit location.
face	See *mining face*.
fishery	An area of water that is being fished. A fishery includes the full area from which fish may be taken by a pound, seine, net, weir or other fishing appliance, and the appliance itself.
flocculation	The process by which suspended or very fine particles in water are assembled into larger masses or floccules that eventually settle out of suspension. This process occurs naturally, but can also be accelerated through the use of chemicals such as alum.
fugitive dust	Dust which is generated by unstable, non-point sources like movement of equipment and the effects of wind and rain on stockpiles and areas stripped of vegetation.

	Fugitive dust is the most common cause of dust complaints at aggregate operations, as it commonly settles on cars and in homes.
grab sample	A single sample or measurement taken at a specific time or over as short a period as is feasible.
grade	The elevation of the ground surface. *Existing grade* is the grade prior to disturbance. *Rough grade* is the stage at which the grade approximates the final finished grade. *Finish grade* is the final grade of the site *Grading* is any excavating, filling, removing or placement of material, or combination thereof.
gravel	Unconsolidated materials that are made up of rock fragments 2 mm to 75 mm in diameter.
ground water	Water that passes through or stands underground in porous rocks and soils, in the zone of saturation, that is under a pressure equal to or greater than atmospheric pressure and supplies wells. The Ministry of Water, Land and Air Protection is responsible for regulating groundwater quality.
grubbing	The removal of stumps and root systems from the soil.
hybrids	Species of plants or trees created by cross-pollinating two or more other species.
hydroseeding	A process whereby seed, fertilizer, wood fiber mulch and/or other agriculture approved additives are mixed together to form a slurry that, when applied to soil, encourages vegetation growth and is an effective means of erosion control.
leachate	Water or other liquid that has percolated through raw material, product, or waste and contains substances in solution or suspension as a result of the contact with these materials.
lithology	The physical character and composition of a sediment or rock, generally defined by its mineral composition.
loadout facility	Site and equipment for loading gravel into trucks or rail cars, or onto barges.
maximum daily discharge limitation	The highest allowable daily discharge of a pollutant, such as turbidity, measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. The daily discharge is calculated as the average measurement of the pollutant over the day.
mineral resource conservation	The act of reserving the opportunity to extract mineral resources.
mining face	The exposed vertical or near vertical portion of soil or rock that results from mining activity. Shape is generally determined by the reach of loading equipment working on the face.
natural aggregate	Sand, gravel and crushed stone.
net gain	An increase in the productive capacity of habitats for selected fisheries brought about by determined government and public efforts to conserve, restore and develop habitats.
no net loss principle	A working principle by which Fisheries and Oceans Canada strives to balance unavoidable habitat losses with habitat replacement on a project-by-project basis so that further reductions to Canada's fisheries resources due to habitat loss or damage may be prevented.
Notice of Work (NoW)	Notice of Work and Reclamation Program on a Sand and Gravel and/or Quarry Operation. The application for a new or amended *Mines Act* Permit.
overburden	Material below topsoil and above saleable aggregate. Overburden is unconsolidated material between the soil layer (rooting zone) and the bedrock, excluding the economically valuable sand and gravel layers. Overburden is typically comprised of

	glacial till, and/or freshwater or marine sediments. Sand and gravel are often sandwiched between layers of overburden.
overfall	The height above a surface watercourse from which a drainage structure discharges.
perched water table	Ground water trapped above an impervious layer of material such as a clay bed.
pH	The pH of a substance measures its acidity or alkalinity in a scale that ranges from 1 to 14. A ph of 7 is defined as neutral, and large deviations, either above or below this value, are considered harmful to most aquatic life.
pit	Any site where sand and/or gravel is extracted.
pit run	Gravel as found in natural deposits; unprocessed gravel.
pollutant	An inorganic or organic substance or sound in the environment that, because of its chemical composition or quantity, prevents the functioning of natural processes and produces undesirable environmental and health effects or adversely affects the usefulness of a resource. For example, substances that could render water harmful to fish include oil and greases, metals, oxygen-demanding substances, toxic organics, fecal coliform bacteria, and any excessive nutrients and sediment. With respect to water, pollutants include any man-made or man-induced alteration of the physical, biological or chemical integrity of the water.
pollution	Contamination of the environment with objectionable or offensive matter.
proctor	See *Standard Proctor*.
processing plant flow sheet	A conceptual model that attempts to predict processing plant performance. The flow sheet forms the basis for the selection of equipment to meet the processing goals.
progressive / concurrent reclamation	The practice of restoring a worked area at a site using soil, overburden and other materials removed in order to access a new section of the deposit, while extraction is going on elsewhere.
quarry	Any site that is used for the extraction of rock from bedrock to be used for construction purposes.
recycled aggregates	Reprocessing of waste concrete and asphalt pavements into useable aggregates.
red-listed species	Extirpated, endangered or threatened species, subspecies (taxa), or ecosystem in B.C. Refer to *endangered species* for more detailed definitions.
Regional MDRC	Regional Mine Development Review Committee.
rehabilitation	The creation of landforms, land productivity and land uses that are compatible with existing land uses in the surrounding area.
restoration	The re-creation of the original landforms, land productivity, and land uses on a disturbed site.
revegetation	The re-establishment of self-sustaining plant cover on a disturbed site.
rip rap	Loose stone used as a foundation/protection for a breakwater, embankment, mountain trail, etc.
round rock aggregate	Natural aggregate from either a fluvial or glaciofluvial deposit and comprised primarily of rounded particles created by mechanical erosion.
sand	Unconsolidated materials that are primarily composed of coarse, medium and fine mineral particles 4.76 mm (#4 sieve) to 0.074 mm (#200 sieve) in diameter.
scarify	Breaking up hard or compacted materials using a grader.

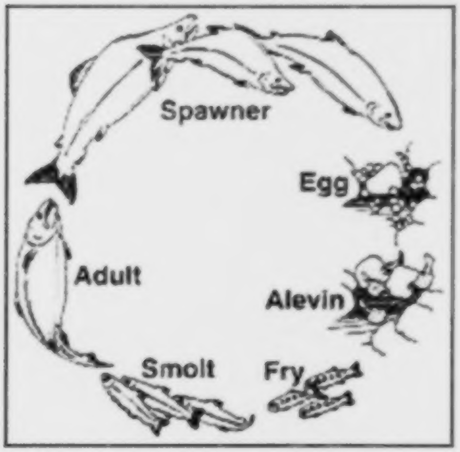
sediment	The very fine material within washing water and storm water runoff, originating from natural, mechanical and human disturbances. Sediment particles originate from the weathering and erosion of rocks or unconsolidated deposits and are transported by, suspended in, or deposited by water or air. Composed of clay, silt and sand.
site	The land or water area where any facility or activity is physically located or conducted or all of the disturbed and undisturbed land within the legal boundaries of a property
soil	The unconsolidated material on the immediate surface of the land that serves as a natural medium for the growth of plants.
stakeholders	All individuals, agencies, bodies, companies, etc. with an interest in a given matter.
Standard Proctor	A test that determines the maximum dry density for specific soil types. Specified compaction densities for fills are often based on a percentage of Standard Proctor for a specific moisture content.
standards	Levels of performance set by regulation or legislation.
sterilization	The removal of access, for whatever reason, to a potential aggregate site for extraction.
stockpiling	The practice of storing materials for later use, sale or disposal.
stormwater	That portion of rainfall and snowmelt runoff that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a stormwater drainage system.
stormwater drainage system	Constructed and natural features that function together as a system to collect, convey, channel, hold, inhibit, retain, detain, infiltrate or divert stormwater.
Superpave	The product of the American Strategic Highway Research Program (SHRP). Superpave (Superior Performing Asphalt Pavements) is an improved system for specifying the components of asphalt concrete, asphalt mixture design and analysis, and asphalt pavement performance prediction.
timing windows	A schedule of certain aggregate operations and mining activities to minimize environmental impacts.
topsoil	The upper-most soil layer that is commonly characterized by dark-coloured, organically-enriched materials.
washing	Practice of cleaning aggregate with water to remove excessive amounts of fine particles.
water quality	The chemical, physical, and biological characteristics of water, normally with respect to its suitability for a particular purpose.
water table	The upper surface or elevation of the groundwater within the aquifer that is closest to the ground surface.

Salmonid Life Histories and Habitat Requirements

Salmonid Life Histories

Anadromous salmonids use the ocean for a major portion of their growth, but depend on freshwater for reproduction. A significant characteristic of anadromous salmonids is their habit of returning from the ocean to spawn in their natal streams, where they were spawned and reared. This homing characteristic has resulted in the development of distinct and separate stocks, each adapted to the particular conditions of its natal stream. There are, therefore, differences between populations in the seasonal timing of adult migration and spawning in freshwater. Each salmonid species is unique in its life cycle and habitat requirements in the freshwater phase. All species of anadromous salmonids require a freshwater environment for spawning and embryonic development, but the species differ in the extent to which they rear in freshwater after emerging from the spawning gravel as fry. Pink and chum salmon migrate to sea immediately following emergence, while the other species rear in streams, lakes or estuaries for periods of months to several years before entering saltwater. The generalized life cycle of the anadromous salmonid is shown in the following figure.

Image A2 - 1: Generalized life cycle of anadromous salmonids



There are significant differences in the life histories of the Pacific salmon, trout and char. While Pacific salmon die after spawning, trout and char may survive to spawn more than once. Salmon and char characteristically spawn in the fall, in declining temperatures, whereas trout spawn in winter or spring, when water temperature generally rises. All species use the gravel bottom of streams or upwelling groundwater sources for spawning sites. The spawning nest or redd, which is constructed by the female, consists of a series of pockets in the gravel in which fertilized eggs are deposited and buried to a depth of 20 to 50 cm. Development of the embryo proceeds from the egg stage to hatching, then through alevin development to full absorption of the yolk sac, and eventually to emergence of fry from the gravel. The period from spawning to fry emergence may range from as little as 2 months in the case of spring-spawning trout, to as much as 9 months for those Pacific salmon populations spawning in colder periods, where temperatures close to 0°C prevail through most of the winter. In the latter case, spawning would likely occur in early to mid-September, eggs would reach the eyed stage (when the eyes, head and body form of the embryo first become apparent) during October, hatching would occur in the following March and April, and the fry would emerge during May. With the exception of the coastal cutthroat trout and anadromous Dolly Varden char, which use near-shore inter-tidal and estuarine areas, many races of anadromous salmonid species migrate extensively for feeding in the Pacific Ocean. They range between northern California and the Gulf of Alaska, and can be found up to 1600 km offshore. Other races of salmonid species remain and feed in coastal waters, such as Georgia Strait, throughout the marine portion of their life. Several species of trout and char have exclusively freshwater life histories where adult migration, spawning, incubation and rearing all occur in, and between, lakes, rivers and streams.

Salmonid Habitat Requirements

Salmonids are a group of fishes adapted to the variable habitat of north temperate, "recently" deglaciated regions. Individually, they often have to cope with severe and variable conditions and as a result might be thought of as an especially "tough" or "insensitive" group of species. They appear to be remarkably resilient in habitat use, in feeding, growth and reproduction, as well as in many other ecological and behavioural characteristics. Despite this, they are environmentally sensitive fishes, particularly with respect to the habitat and water quality requirements of the incubating and rearing portions of their life cycle. The typical food items for those species that use streams for nursery purposes are terrestrial and aquatic invertebrate animals whose own life cycles depend on similar habitat and water quality characteristics as salmonids.

Salmonids have different habitat requirements for each life stage, but generally they need fairly cool, well-oxygenated water, a clean gravel substrate, and abundant cover and shade. They need special conditions for successful spawning, for the subsequent development and hatching of eggs and for growth and survival of their young. Fry and juveniles move to different habitats as they grow older, and hence they require access up and down the stream and into smaller tributaries. This may include swampy areas, wetlands, small streams and side channels or intermittently wetted areas. These vital areas may sometimes not seem like appropriate habitat to the untrained eye. Adult salmonids require adequate flow and access to spawning areas for completion of their life cycle.

The range and diversity of aquatic environments the various salmonids inhabit throughout their life history combine to make them much more vulnerable to environmental changes. These changes are generally associated with water use and impacts of land use activities on the aquatic environment. Water diversions and pollution, hydroelectric projects, forest harvesting, road construction and land development can each adversely affect salmonids. Their habitat use varies widely with species and also with races of a species, between discrete populations and even between individuals of the same population. This makes it difficult to generalize about their areas of preference and habitat requirements. It also means that salmonid habitat protection and management must be based on specific and up-to-date information about local populations and conditions.

Specific environmental requirements of salmonids vary with species; the requirements of different species may even be in direct conflict (e.g., a small log jam may create a nursery area for coho salmon but remove a spawning area for chum or pink salmon). The following is a generalization of the optimum requirements of the habitat characteristics and water conditions of the salmonid freshwater environment:

Water Temperature

A temperature between 12 and 14°C is preferred by the young of all salmon species, with marked avoidance of temperatures above 15°C, and fatality at temperatures of about 24-25°C. Increased stream temperature means more dissolved oxygen (DO) is needed for the increased metabolic rate of fish. However, DO saturation levels decrease with increasing temperature, so lower concentrations of DO are available as temperatures rise.

Dissolved Oxygen (DO)

Stream-dwelling salmonids require high levels of DO in both the intragravel and surface waters. It is difficult to set down useful minimum oxygen requirements for stream salmonids given the great diversity of requirements for different life stages, activities and stresses any population experiences. It must be stressed that temperature and water quality markedly affect the levels of DO saturation (i.e., percentage of total saturation at a given temperature) and concentration (mg/l) in stream waters. Generally, optimum DO saturation is greater than 90% and minimum optimum DO concentration is greater than 8 mg/l.

Water Clarity and Suspended Sediment

Stream water must be clear enough to permit the sunlight to reach the stream bottom and the algal community where most of the primary production of a stream occurs. Elimination of such production may severely reduce the invertebrate fauna of a stream. Salmonids feed by sight and can have difficulty finding food items in highly turbid water. High concentrations of suspended solids may also directly damage invertebrates and fish, primarily their fragile gill structures. Additional impacts can occur if suspended sediments settle onto stream bottoms and suffocate Incubating salmonid eggs and alevins, and destroy benthic invertebrate populations.

Stream Substrate

For successful spawning, salmonids require clean stable gravel, typically located in riffles or runs, depending on fish size and species. High quality gravel will permit redd building and an intragravel flow of water adequate to provide each embryo and alevin with a high concentration of dissolved oxygen and to remove metabolic wastes such as carbon dioxide and ammonia. Clean spawning gravel, from 5 mm to 150 mm in diameter, and larger rocks and cobbles, found on the stream bottom and banks, is required for production of aquatic insects and habitat for young juvenile salmonids.

Riparian Cover and Stream Structure

Stream salmonids require cover in the form of undercut banks, logs, rubble substrate, turbulence, deep pools and overhanging streamside vegetation as found in a viable healthy riparian area. Such cover is used by juveniles for feeding areas, as a source of food items, and as refuge for escape and over-wintering. Adult salmonids use deep pools as cover for resting and escape during spawning migrations. Research has also shown that in order to have substantial mixed populations of salmonids, such as the commonly found associations of steelhead trout and coho salmon or cutthroat trout and coho, a stream with a stepped gradient and high proportion of both riffles and pools is required. Large organic debris (LOD) forms an integral part of the stream morphology by stabilizing the streambed, by providing habitat, and by altering the stream structure with scours and pools. Naturally occurring LOD, such as fallen logs, root wads and small jams, should not be altered or removed.

Access

The spawning and nursery areas of streams must be accessible to adult salmonids migrating upstream, and to fry and juveniles seeking rearing habitat. This includes small feeder streams, wetlands and side channels, which provide valuable habitat in the stream or river environment.

Stream Flow

A relatively stable flow, without extreme freshets and droughts, characterizes the best salmon and trout streams. Stable stream flow is characterized by a minimum of freshets and floods causing excessive bed load transport and bank instability, consequently destroying benthos or any developing embryos or alevins that might be in the substrate. While too much water might be detrimental, too little is also damaging. A sufficient flow of water is required for each life stage. Sufficient flows are required during the normal low flow period of late August and September to provide adequate nursery area for the young salmonids and access for returning spawners, and also during the winter, when embryos and alevins in the gravel could be exposed to freezing.

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Appendix 4 - AGGREGATE & GOVERNMENT ACRONYMS

Term	Definition
AASHTO	American Association of State Highway and Transportation Officials
ALR	Agricultural Land Reserve
ARD	acid rock drainage
ASTM	American Society for Testing and Materials
BCAL	British Columbia Assets and Land Corporation (replaced by LWBC)
BMP	Best Management Practice
C&E	Compliance and Enforcement Branch, British Columbia Ministry of Forests
CDC	Conservation Data Centre, British Columbia
CEMA	Convevor Equipment Manufacturer's Association
CSA	Canadian Standards Association
dB	decibels, a unit of measure of sound
dBA	approximate sound to the human ear
DFO	Fisheries and Oceans Canada
DETR	Department of the Environment, Transport and the Regions, United Kingdom
EAO	Environmental Assessment Office
EC	Environment Canada
FLR	Forest Land Reserve
FSR	forest service road
H/C	hydrocarbons
HSRC	Health, Safety and Reclamation Code
LRC	Land Reserve Commission
LWBC	Land and Water British Columbia (formerly BCAL)
MAFF	British Columbia Ministry of Agriculture, Food and Fisheries
MASHA	Mines and Aggregates Safety and Health Association
MB	Mines Branch, British Columbia Ministry of Energy and Mines
MCAWS	British Columbia Ministry of Community, Aboriginal and Women's Services
MDC	Mine Development Committee
MEM	British Columbia Ministry of Energy and Mines
MEX	Materials Exchange, Recycling Council of British Columbia
ML/ARD	metal leaching and acid rock drainage
MOF	British Columbia Ministry of Forests
MOT	British Columbia Ministry of Transportation
MSRM	British Columbia Ministry of Sustainable Resource Management
MWLAP	British Columbia Ministry of Water, Land and Air Protection
NOW	Notice of Work

NRCS	Natural Resources Conservation Service, US Department of Agriculture
NSA	National Stone Association
NTS	National Topographic System
OCP	Official Community Plan
OHSC	Occupational Health and Safety Committee
pH	measure of acid or alkalinity of a solution or substance
PM_{10}	dust particle of 10 micrometres - unit of measure for fugitive dust particles
RCBC	Recycling Council of British Columbia
RTEB	Resource Tenures and Engineering Branch, British Columbia Ministry of Forests
SEI	Sensitive Ecosystem Inventory
SUP	Special Use Permit, British Columbia Ministry of Forests
TRIM	Terrain Resource Information Management
TDS	total dissolved solids
TSS	total suspended solids
USDA	United States Department of Agriculture
WHMIS	Workplace Hazardous Material Information System

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for

BRITISH COLUMBIA

VOLUME II

Best Management Practices

(**Volume I** - Introduction & Planning
as separate printable document)

British
Columbia

Ministry of
Energy & Mines

April 2002

PART III - BEST MANAGEMENT PRACTICES

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Chapter 7

Best Management Practices

Introduction

This chapter of the handbook presents thirty-seven Best Management Practices (BMPs). The BMPs have been selected for specific application in aggregate operations. There are, however, many "general reference" BMPs that can also be useful. Three recommended websites are:

1. *Water Related BMP's in the Landscape.* Watershed Science Institute. URL <http://www.abe.msstate.edu/csd/NRCS-BMPs/>, October 2001

2. *Best Management Practices for Reclaiming Surface Mines in Washington and Oregon.* URL <http://www.wa.gov/dnr/htdocs/ger/pdf/bmp.pdf> [PDF, 7.6 Mb], June 2001, and

3. *Stormwater Management Manual for Western Washington*, Volumes I-5 Washington State Department of Ecology, URL <http://www.ecy.wa.gov/biblio/9911.html>, June 2001 (scroll to the bottom of the page for links to volume 2-5).

Also see the "Additional BMP Websites" section at the end of this introduction.

How to Chose BMPs

There are three ways to select a BMP from this handbook:

1. Refer to Table 7-1 and 7-2 BMP Module Reference Charts.
In these charts, BMPs are cross-referenced against Module topics (extraction, traffic, etc.). Table 7-1 organizes the BMP's into five thematic groupings (Stormwater Mangagement, Erosion Control, Noise and Dust, Risk Management and Pollution Prevention), while Table 7-2 lists them alphabetically.

2. Review Topical Modules for Suggestions
Tables within the Chapter 5 modules suggest specific BMPs to address specific problems.

3. Flip Through the BMPs in Chapter 7
The BMPs in Chapter 7 all have a "USE" box in the upper right hand corner of the first page. They can be selected by simply looking for a "USE" box with an appropriate application.

Additional BMP Websites

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Table 7 - 1: BMP - Module Reference Chart

	MODULES	EM	PM	SM	TM	SECM	BWM	SLM			RM					
GROUPIN	Topics: / BMPs	Extraction	Processing	Stockpiling	Traffic	Stormwater & Erosion	By-product & Waste	Noise	Dust	Visual Landscape	Risk Management	Emergency Spill Rsep.	Employee Training	ID Env. Issues	Community Relations	BMP Monitoring
Stormwater Mgnt	Buffer Zone	✓	✓	✓		✓		✓	✓	✓		✓		✓	✓	✓
	Check Dams			✓		✓										✓
	Constructed Wetlands		✓			✓				✓				✓	✓	✓
	Ditches		✓	✓		✓										✓
	French Drain					✓										✓
	Retention Basin															✓
	Silt Fence	✓		✓		✓			✓							✓
	Slope Drain					✓										✓
Erosion Control	Backfilling	✓	✓	✓		✓	✓	✓								
	Bioengineering			✓		✓			✓	✓						✓
	Erosion Control Blanket	✓		✓		✓			✓							✓
	Grading	✓	✓	✓		✓	✓		✓	✓						
	Outlet Protection		✓			✓					✓	✓				✓
	Tarps		✓	✓	✓	✓			✓							✓
	Tillage	✓		✓		✓			✓							✓
	Topsoil management		✓	✓		✓			✓							✓
	Vegetation Cover	✓		✓		✓		✓	✓	✓				✓	✓	✓
Noise and Dust	Berm			✓		✓	✓	✓	✓	✓					✓	✓
	Drop Height	✓	✓	✓	✓			✓	✓							✓
	Dust Skirt	✓	✓	✓	✓				✓							✓
	Equipment Selection	✓	✓	✓	✓		✓	✓	✓			✓	✓		✓	
	Haul Roads				✓	✓		✓	✓	✓	✓			✓	✓	✓
	Material Corrals		✓	✓	✓	✓	✓		✓	✓						✓
	Sinking the Plant		✓		✓			✓	✓	✓						✓
	Street Cleaning		✓		✓	✓	✓		✓	✓				✓	✓	✓
	Vibration Reduction	✓	✓		✓			✓	✓		✓				✓	✓
	Water Spray	✓	✓	✓	✓	✓			✓							✓
	Wheel Washer		✓		✓	✓			✓	✓					✓	✓
	Wind Protection			✓					✓	✓						✓

	MODULES	**EM**	**PM**	**SM**	**TM**	**SECM**	**BWM**	**SLM**			**RM**					
GROUPIN	Topics: **BMPs**	Extraction	Processing	Stockpiling	Traffic	Stormwater & Erosion	By-product & Waste	Noise	Dust	Visual Landscape	Risk Management	Emergency Spill Rsep.	Employee Training	ID Env. Issues	Community Relations	BMP Monitoring
Risk Mgnt	**Env. Timing Windows**	✓	✓	✓				✓			✓			✓		✓
	Fences			✓		✓		✓	✓	✓				✓	✓	✓
	Lighting Management	✓	✓	✓						✓	✓	✓		✓	✓	✓
	Signage									✓	✓	✓	✓		✓	✓
Pollution	**Oil/Water Separator**		✓			✓	✓					✓				✓
	Pollution Prevention	✓	✓	✓	✓	✓	✓				✓	✓	✓			✓
	Scheduled Maintenance	✓	✓		✓		✓	✓	✓			✓	✓			✓
	Settling Pond		✓	✓		✓	✓									✓

Table 7 - 2: BMP - Module Reference Chart - Alphabetic

MODULES	EM	PM	SM	TM	SEC	BWM	SLM			RMM					
Topics: / BMPs	Extraction	Processing	Stockpiling	Traffic	Stormwater & Erosion	By-product & Waste	Noise	Dust	Visual Landscape	Risk Management	Emergency Spill Rsep.	Employee Training	ID Env. Issues	Community Relations	BMP Monitoring
Backfilling	✓	✓	✓		✓	✓	✓								
Berm			✓		✓	✓	✓	✓	✓					✓	✓
Bioengineering			✓		✓			✓	✓						✓
Buffer Zone	✓	✓	✓		✓		✓	✓	✓		✓		✓	✓	✓
Check Dams			✓		✓										✓
Constructed Wetlands		✓			✓				✓				✓	✓	✓
Ditches		✓	✓		✓										✓
Drop Height	✓	✓	✓	✓			✓	✓							✓
Dust Skirt	✓	✓	✓	✓				✓							✓
Env. Timing Windows	✓	✓	✓				✓			✓			✓		✓
Equipment Selection	✓	✓	✓	✓		✓	✓	✓			✓	✓		✓	
Erosion Control Blanket	✓		✓		✓			✓							✓
Fences			✓		✓		✓	✓	✓				✓	✓	✓
French Drain					✓										✓
Grading	✓	✓	✓		✓	✓		✓	✓						
Haul Roads				✓	✓		✓	✓	✓	✓			✓	✓	✓
Lighting Management	✓	✓	✓						✓	✓	✓		✓	✓	✓
Material Corrals		✓	✓	✓	✓	✓		✓	✓						✓
Oil/Water Separator		✓			✓	✓					✓				✓
Outlet Protection		✓			✓					✓	✓				✓
Pollution Provention	✓	✓	✓	✓	✓	✓				✓	✓	✓			✓
Retention Basin															✓
Scheduled Maintenance	✓	✓		✓		✓	✓	✓			✓	✓			✓
Settling Pond		✓	✓		✓	✓									✓
Signage									✓	✓	✓	✓		✓	✓
Silt Fence	✓		✓		✓			✓							✓
Sinking the Plant		✓		✓			✓	✓	✓						✓
Slope Drain					✓										✓

MODULES	**EM**	**PM**	**SM**	**TM**	**SEC**	**BWM**	**SLM**			**RMM**					
Topics: **BMPs**	Extraction	Processing	Stockpiling	Traffic	Stormwater & Erosion	By-product & Waste	Noise	Dust	Visual Landscape	Risk Management	Emergency Spill Rsep.	Employee Training	ID Env. Issues	Community Relations	BMP Monitoring
Street Cleaning		✓		✓	✓	✓		✓	✓				✓	✓	✓
Tarps		✓	✓	✓	✓			✓							✓
Tillage	✓		✓		✓			✓							✓
Topsoil management		✓	✓		✓			✓							✓
Vegetation Cover	✓		✓		✓		✓	✓	✓				✓	✓	✓
Vibration Reduction	✓	✓		✓			✓	✓		✓				✓	✓
Water Spray	✓	✓	✓	✓	✓			✓							✓
Wheel Washer		✓		✓	✓			✓	✓					✓	✓
Wind Protection			✓					✓	✓						✓

MAP CODE
BKFL

BACKFILLING

USE
Risk
Management
Rehabilitation

What

- Using lifts of overburden or waste rock to restore a face or a mined out area to a specified reclamation slope.

Purpose

- Reduces slope angles to specific or standard reclamation criteria.
- Can reduce the hazard of slope failure.
- Compaction may be required to achieve a specified minimum density.

Where

YES: Where final face heights are higher and steeper than permit specifications or general reclamation standards.

Materials, Equipment & Costs

🚚 Overburden, waste rock, construction or excavation materials.

⚒ Haul truck, front-end loader, bulldozer, backhoe, sheep's foot roller and smooth vibrating drum roller.

$ Variable, depending upon height, moisture content and post-extraction land use.

Specs

- A sand and gravel or quarry permit may specify reclamation slope angles and compaction specifications (dry densities of backfilling material, standard proctor, and compaction techniques). If slope angles are not specified in the permit, use general reclamation slope angles of 2 horizontal to 1 vertical.
- If in doubt regarding reclamation specifications, contact a regional office of the Ministry of Energy and Mines or the Mines Branch, Geotechnical Section, in Victoria.
- After all mineable aggregate is removed from an area, slopes can be re-contoured by:
  - concurrent backfilling using overburden mined elsewhere on the site;,
  - bringing in quality, clean fill material from construction projects or other sources offsite, and
  - retaining enough overburden or mine by-products for re-sloping.
- Backfilling is most efficient when stripped waste material is immediately placed into backfilling lifts. Using this approach, the material is handled only once, and its original moisture content may allow for the best compaction. The moisture content of stockpiled waste material may change during storage, making it difficult to achieve the required minimum density.
- Ensure that fill material is free of brush, rubbish, organics, logs, stumps, building debris and other materials inappropriate for constructing stable fills.
- Ensure that fills from unknown sources are free of contamination.
- Place fill in 6 centimeter layers, or other thickness specified in the design.

- Compact the layers to the required standard proctor dry density, as required, to ensure stability.
- Add water during compaction, as required to maintain optimum moisture content.
- Clay is best compacted with a sheep's foot roller, and granular material with a smooth vibrating drum roller.
- If overburden cannot be immediately placed into lifts, store the overburden where it can be readily and economically moved into position during reclamation.
- Plan stormwater drainage paths.

Additional Considerations

- Stability and erosion control are primary concerns for backfilled slopes. Careful location of drains and water-control features will enhance slope stability and revegetation potential.
- If overburden or waste rock is strategically placed and there are no geotechnical concerns, backfilling may be done with a short push or haul.
- Back-slope benches should drain stormwater away from the crests.
- Backfilling areas proposed for buildings and roads may require increased density criteria and testing for control of compaction and grade.
- If permanent planting will be delayed, temporary protection of bare slopes against erosion with plastic sheeting, mulches, matting or seeding with grasses may be necessary.

Options

- For sand and gravel pits, if no material is available for backfilling, simply knocking down the crest of the face can reduce the slope to the desired stable slope angle. Proper safety measures should be taken.

Vegetation & Planting

- Vegetation can significantly reduce surface erosion, but cannot be relied upon to prevent movement of a soil that is unstable due to improper design and construction.
- Planning a phased succession for ground cover, grasses, shrubs and trees will establish good protection. Succession management involves the addition of naturally occurring types of plants, as the indigenous species create an environment in which further stages can flourish. For example, shade-loving species should not be planted in full sun, but would naturally begin to appear after the development of a canopy.

Maintenance

- It is important to establish and maintain drainage to avoid flooding or erosion.
- Ensure that the vegetative cover is kept healthy, to avoid erosion.

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MAP CODE
BERM

BERM

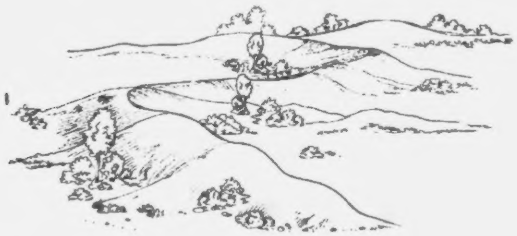
USE
Dust
Noise
Landscape

What

- An elongated, raised barrier constructed of overburden, topsoil or aggregate by-product, commonly seeded with grass and topped with shrubs, trees and/or a fence.

Purpose

- To intercept noise, dust and the views of an operation.
- For site security by deterring trespass.
- A storage option for overburden, waste rock or by-products and, at times, product.
- When well designed, constructed and vegetated, berms can help the operation to blend in with the landscape and the local community.



Where

YES: Adjacent to noise, dust or visual impact sources; adjacent to areas senstive to impacts (e.g., wetlands, schools, residential areas); around the perimeter of the property; most commonly located anywhere between operations and residential areas or public roads.

Materials, Equipment & Costs

- Overburden, pit run, waste rock, aggregate by-products, sand or gravel, trees, shrubs, grass seed and fencing materials. Constructing a berm out of top soil may restrict the topsoil's availability for reclamation work.
- Haul truck, bulldozer, front-end loader and labour to plant vegetation and build fences.

$ Medium.

Plans & Specs

- The slope, size, shape, grade and vegetation of the berm should blend into the local landscape and be similar to what is naturally found. Poorly planned and constructed berms may actually be an eyesore.
- Berm height to width ratios range from 1:5 to 1:10; tops are usually at least 2.0 metres above adjacent surfaces.
- Choose fertile, non-droughty soil materials to minimize the need for watering and ensure successful revegetation.
- A landscape architect or designer can be enlisted to help ensure the berms achieve their design goals, and can assist with the landscape planning.

- Examples of well-designed berms can often be found on golf courses.
- To achieve a more natural appearance, vary the height of the berms, widen them out or otherwise change their shape, and give them gentle curves.
- Round off the crest to facilitate planting.
- Blend the base into existing grades.
- Use landscaping to further blur the berm-grade line. For example, a lawn that exactly follows the toe of the slope is a dead giveaway. Instead, allow the lawn to cross the line in natural "mowable" curves.
- Retaining walls of concrete blocks can form the back of berms in tight spaces.
- Establish ground cover quickly, using sod if appropriate. Use geotextiles, straw matting, shrubs and trees to further reduce the erosion potential of the berm. Refer to Erosion Control Blanket BMP.

Vegetation & Planting

- For noise and dust control and visual screening, plant a mix of fast-growing shrubs and deciduous trees with slower-growing evergreens. Weeping willow trees or various native willow shrubs add diversity.
- Before planting, consider the expected life span of the berm (5 year, 20 year, "permanent") and take into account the final land use and the role of the berm after the completion of the mine.
- For a more natural look, plant trees or shrubs in a staggered pattern off the crest of the berm, and plant in groupings rather than in rows.
- Berms usually drain well and dry out quickly, so select plants that are relatively drought tolerant or fit the mound with a drip irrigation or sprinkler system. Sprinklers also have the advantage of dust suppression abilities.
- For detailed information, refer to the Land Reserve Commission's (LRC) publication "Landscape Buffer Specifications," available at http://www.landcommission.gov.bc.ca under "Publications/ALR Topics/". This document was written for the agricultural industry, but also can be useful for aggregate operations.

Maintenance

- Plants, shrubs and trees require maintenance such as fertilization, thinning and pruning. In creating inconspicuous buffers, consider a natural but neat look. Both finely sculpted hedges and dead snags may be undesirable.
- A regular program of irrigation, fertilization and weed control may be required.

Sources:

Totten, L.B. (1997): **Outside Interests;** The Detroit News, 27 November, 1997.

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MAP CODE
BIOE

BIOENGINEERING

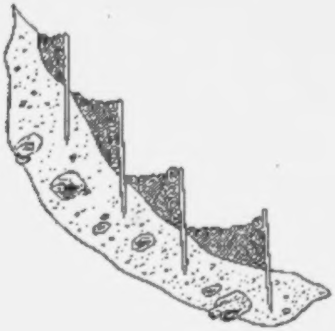
USE
Erosion
Sediment
Stormwater

What

- Erosion and sediment control structures made from stalks of live willow shrubs that continue to grow once emplaced into the soil.

Purpose

- To prevent erosion with their physical structure until established plants can provide permanent erosion protection.
- To jump-start the establishment of self-sustaining vegetation on exposed hillsides and gullies, which stabilize the slopes and stop erosion and sediment production.



Source: Polster Environmental Services

Wattle Fencing - Sideview

Where

YES: Areas of disturbed soil or hillsides, streambanks and lakeshores, and where soil stabilization and erosion control is required because of stormwater runoff or high water table.

NO: Areas where there is severe soil or water contamination, the stream bottom is degrading, human or animal traffic cannot be controlled, or where shade is too dense for selected plant species to thrive.

Materials, Equipment & Costs

- Live willow stakes, timber stakes, twine, rope, pots or mats, plant material
- Backhoe, shovel, sledge hammer.
- $ Low to medium.

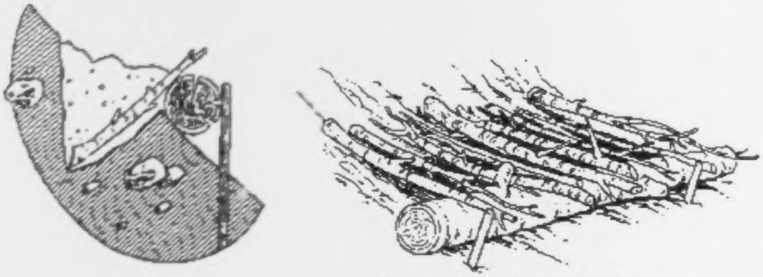
Plans & Specs

- If using for first time, consider obtaining expert help from environmental or erosion control engineers and/or consultants.

Options

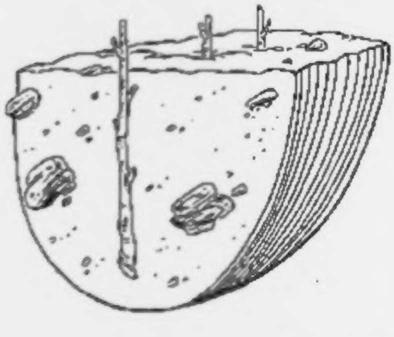
- Wattle Fence
  Small retaining walls built of willow stakes. Useful on hill slopes and gullies with minimal ravelling.

- Modified Brush Layer
  Robust short retaining walls (1-2 metres wide) made with 2 metre long rough cut 2x6 planks or logs and live willow stakes. Excellent for stabilizing ravelling or actively eroding hill slopes and gullies. Used in patterns to give complete coverage of a hillside or gully wall.



Source: Polster Environmental Services

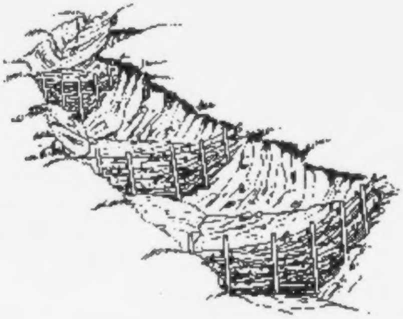
- Live Cuttings
  Stakes of willow planted into exposed or eroding hill slopes and gully walls. Provide quick coverage of shrubs over an entire area and are effective alone or between modified brush layers.



Source: Polster Environmental Services

Live Staking

- Live Gully Breaks
  Large wattle fences constructed across an eroding channel. Live gully breaks are designed to control the initiation of torrenting by reducing the effective gradient of the eroding channel.



Source: Polster Environmental Services

- Interplanting Riprap
  Riprap is often used to protect stream banks and lakeshores. Live cuttings can be inter-planted in riprap to provide additional slope stability. Root growth below the riprap will improve soil strength and live vegetation will hide the rocks, providing a more natural look.

Maintenance

- Provide regular monitoring and maintenance, especially in the first year, to assure adequate plant survival.
- Be aware that flood or drought conditions could impact the installation. Severe weather will reduce seedling survival and supplemental planting may be needed.

Sources

Polster, D. (1998): **Introduction to Soil Bioengineering;** *British Columbia Ministry of Forests,* Resource Tenure & Engineering Brach.

Thomas G. F. (1997): **Bioengineering for Hillslope, Streambank and Lakeshore Erosion Control.**; *Institute of Agriculture and Natural Resources,* University of Nebraska-Lincoln

Lewis, L., Salisbury S.L. and Hagen, S. (2000): **Soil Bioengineering for Upland Slope Stabilization;** *Washington State Department of Transportation,* Research Project WA-RD 491.1.

MAP CODE
BFZN

BUFFER ZONE

USE

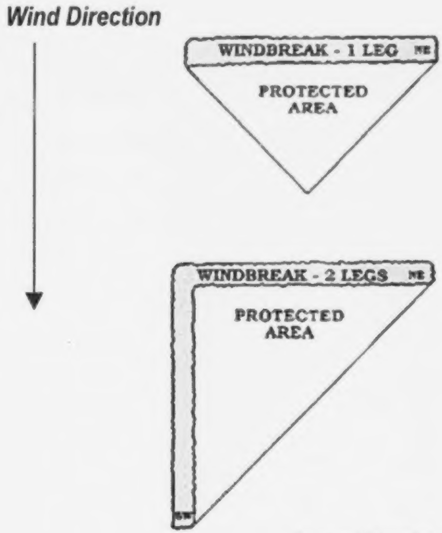
Dust
Erosion/Sediment
Noise
Stormwater
Site Environmental
Visual

What

- A naturally vegetated or replanted area around the perimeter of the aggregate site, or adjacent to an environmentally sensitive area such as a stream, wetland or urban development.

Purpose

- To minimize erosion, improve water quality, intercept dust, reduce noise, act as a wildlife corridor or enhance the visual appearance of the operation with trees, shrubs and plants.
- To reduce pollution into streams and reduce the flow and velocity of stormwater.
- To reduce and redirect wind. A buffer zone can reduce wind speeds on both the leeward and windward sides of an operation, which can reduce dust and noise being carried off-site.



Source: University of Nebraska-Lincoln

Where

- Around the site perimeter, along roadways or ridges, at the edge of any disturbed areas or adjacent to perennial streams or permanent water bodies.
- Alongside stormwater ditches to help reduce the amount of sediment and pollution in the water.
- Perimeter windbreaks of trees and shrubs can protect areas subject to erosion and dust generation due to wind, intercept noise and dust, and provide a visual barrier.

Materials Equipment & Costs

Native trees, shrubs, seeds and fertilizer.

Backhoe for trees, shovels, labour.

$ Low to medium.

Plans & Spec's

- A *Mines Act* permit may specify buffer widths.
- A windbreak density of 40% to 60% provides the greatest downwind area of protection, as well as excellent soil erosion control.
- If density is below 20%, the windbreak does not provide useful wind reduction. If density is above 80%, excessive leeward turbulence may reduce the windbreak effectiveness.
- Work around streams is regulated by statutes, regulations and guidelines administered by agencies such as Ministry of Water, Land and Air Protection and Fisheries and Oceans Canada (see Chapter 3).
- Where a natural buffer zone is not available, or the recommended zone width is not attainable, alternatives such as flow barriers, diversions, sediment traps, vegetative planting and silt fences may be used. Use of these alternatives may require government approval.
- Runoff from the disturbed areas should be allowed to spread out over the entire length of the buffer zone, and not channelled into a single discharge point within a buffer zone.

Relative effectiveness of different vegetation types for providing specific buffer zone benefits

Benefit	Vegetation Type		
	Grass	Shrub	Tree
Stabilize bank erosion	Low	High	High
Filter sediment	High	Low	Low
Filter nutrients, pesticides, microbes			
• Sediment bound	High	Low	Low
• Soluble	Medium	Low	Medium
Aquatic habitat	Low	Medium	High
Wildlife habitat			
• Range/pasture/prairie wildlife	High	Medium	Low
• Forest wildlife	Low	Medium	High
Economic products	Medium	Low	Medium
Visual diversity	Low	Medium	High
Flood protection	Low	Medium	High
Dust control	Low	High	High
Noise reduction	Low	High	High

Source: NRCS Planning & Design Manual, NRCS

British Columbia shrub species which lend themselves to buffer zone application are:

- ⇒ Red Osier Dogwood
- ⇒ Yellow Twig Dogwood
- ⇒ Beaked Hazelnut
- ⇒ Wolf-willow/Silverberry
- ⇒ Ocean Spray
- ⇒ Twinberry
- ⇒ Tall Oregon Grape
- ⇒ California Lilac
- ⇒ California Waxmyrtle
- ⇒ Indian Plum/Oso Berry
- ⇒ Sitka Alder
- ⇒ Smooth Sumac
- ⇒ Red Flowering Currant
- ⇒ Nootka Rose
- ⇒ Snowberries
- ⇒ Thimbleberry
- ⇒ Salmonberry

Maintenance

- Little or none required except in the case of newly planted material, which will need adequate water (and perhaps fertilizer) until established.
- Simple pruning of bushes and trees will produce a thicker, sturdier growth.

Sources

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MAP CODE
CKDM

CHECK DAM

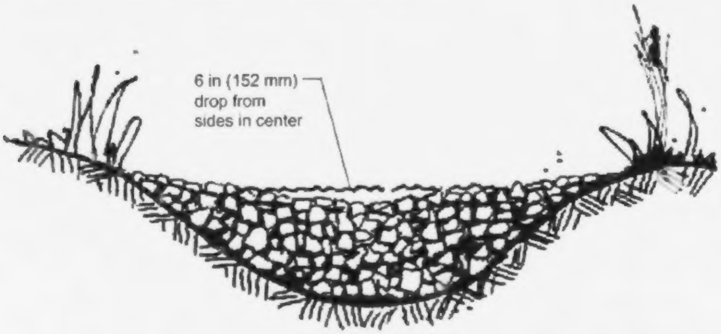
USE
Erosion
Stormwater
Pollution

What

- A small temporary dam within a ditch, drainage, swale or channel.
- Made of rocks, straw, logs, lumber or interlocking pre-cast concrete blocks.

Purpose

- To reduce the gradient of a ditch, slowing the water, lowering its ability to cause erosion, and allowing sediment to settle out.



Rock Check Dam
Section View

Where

YES: Ditches, channels, swales, constructed waterways, or conveyance structures.

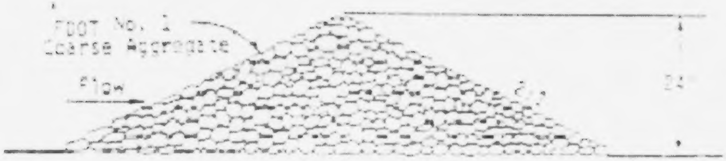
NO: Natural watercourses, any watercourses containing fish (whose passage might be blocked).

Materials, Equipment & Costs

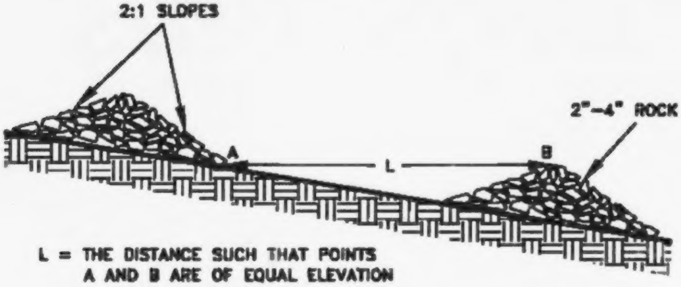
- Rocks, (pea gravel up to 4 inches), sand bags, gabions (wire baskets of rocks), straw bales, logs, lumber, rubber tubes inflated with water or interlocking pre-cast concrete blocks.
- Back hoe and labourer.
- $ Low.

Plans & Specs

- Maximum height should be about 0.6 metres, with a 0.25 metre notch or "V" in the centre to control the flow.
- If using granular material, the check dam should have a triangular cross section, with slopes of 2 horizontal to 1 vertical or less.
- Use non-erodible material (gravel, cobble, etc.) wherever water is concentrated (high velocity) or drops or flows rapidly over the structure.



- Keep the top of the check dam about 0.3 metres below the top of the ditch or the ground elevation.
- If heavily sediment-laden flows are regularly expected, construct a sump immediately upstream of the check dam..
- Keystone the check dam materials up to 0.5 metres into the banks.
- Space the check dams so that the toe of the upstream check dam is the same elevation as the top of the downstream check dam (see figure).


2:1 SLOPES
2"–4" ROCK
A
L
B
L = THE DISTANCE SUCH THAT POINTS
A AND B ARE OF EQUAL ELEVATION

- When using non-granular materials such as boards or straw bales, place rip rap below the outfall to prevent erosion.
- Temporary check dams should be removed when no longer useful; when permanent channel linings, such as grass, have been established,for example.

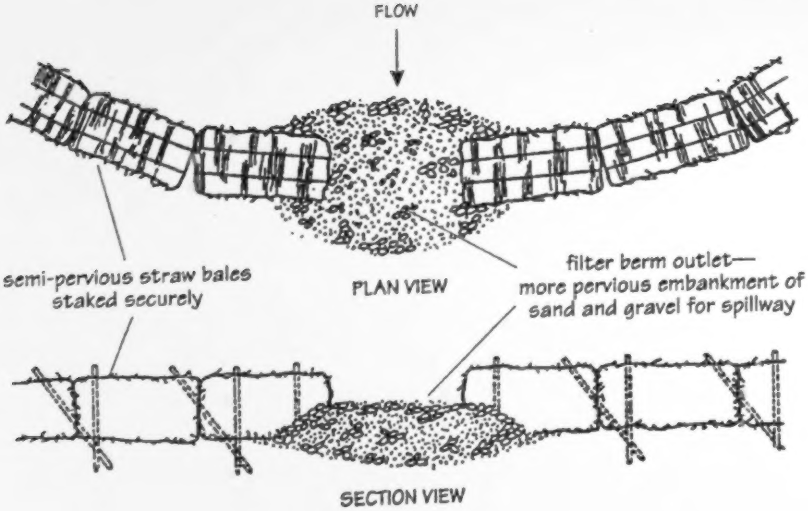
Options

Filter Fabric

Filter fabric can be used under a rock or sandbag check dam to help prevent sediment from flowing through the dam. The bottom of the fabric should be anchored in a trench.

Straw Bale Check Dam

Straw bales by themselves can be used in minor swales and ditches where the drainage area is less than 1 hectare, or where they will be pulled out in three months or less. The following diagram illustrates an effective use of straw bales in ordinary check dam installations.


FLOW
semi-pervious straw bales staked securely
PLAN VIEW
filter berm outlet—more pervious embankment of sand and gravel for spillway
SECTION VIEW

Log Check Dam

Log check dams are composed of upright 4 to 6 inches (100-150 mm) boards or logs, embedded in the soil a minimum of one half metre. Log check dam may be composed of material salvaged from clearing operations.

Maintenance

- Expect deposition above the dam and erosion around the sides and bottom. Areas of deposition should be cleaned out or repaired as necessary, and rip rapped if required.
- The check dam should be inspected during and after large storms or extended periods of rain for erosion around top edges, scour and infilling.
- Remove the sediment when it reaches half of the sump or dam height.

Sources

Austin, L. (2001): **Construction Stormwater Pollution Prevention;** *in* Stormwater Management Manual for Western Washington, Volume II. *Washington State Department of Ecology*, Publication 9912, URL <http://www.ecy.wa.gov/biblio/9912.html>, June 2001.

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MAP CODE
WTLD

CONSTRUCTED WETLANDS

USE
Stormwater
Visual
Site Environmental

What

- A modified natural or constructed shallow pond for the treatment of sediment-laden waters by wetland vegetation.

Purpose

- Receives and temporarily holds sediment-laden waters to prevent downstream surface water pollution and to provide biological treatment to help meet acceptable turbidity/suspended solids (TDS) standards.

Photo: Sedun

Where

YES: Where there is adequate space and where runoff may have moderately elevated total suspended solids, oils, pesticides, or nutrients that would be unsuitable for downstream receiving waters.

Materials Equipment & Costs

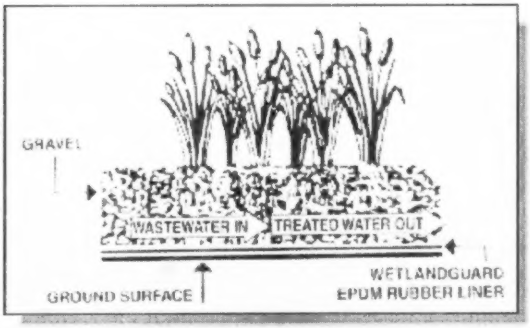
- Suitable land area, liners (if required), inlet and overflow plumbing, fish trap, plants, native vegetation and soils.
- ⚒ Earth moving equipment, labour.
- $ High.

Plans & Spec's

- The principle behind constructed wetlands is that incoming storm runoff displaces old water, which flows out of the pond. The new runoff is stored in a permanent pool in the pond until the next storm. This situation creates long detention times and high cleansing rates.
- The contributing drainage area to the wetland should be examined for potential contamination sources such as oil from roads and parking areas, yard spray

(pesticides), fertilizer residue, building or driveway washdowns, and runoff from stored materials, debris or bare soil areas.

- The soils at the wetland site should be sufficiently impermeable to be able to hold the turbid water for treatment and protection of the area groundwater.
- The constructed wetland should have sufficient detention volume to store storm runoff volume or the "first flush" of runoff which contains the majority of pollutants.
- The treatment rate is a direct function of the size of the pond: the larger the pond, the greater the treatment removal rate.
- A unique feature of wetlands is the presence of aquatic plants and algae that can remove significant amounts of soluble nutrients from stormwater, effectively reducing downstream algal growth.
- Install a fish guard/barrier or sediment trap to prevent fish from entering and inhabiting the wetland.



Installation

- Consult with environmental professionals.

Maintenance

- Clean out excessive sediment at intake.
- Remove excess plant build-up.
- Remove excessive siltation from the entire pond, one section at a time.

Sources

National Conference on Urban Runoff Management: (1993) **Enhancing Urban Watershed Management at the Local, County and State Levels**.

United States Department of Agriculture, (1994) **Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater, Best Management Practice Standards.**

National Risk Management Research Laboratory, **Constructed Wetlands Treatment of Municipal Wastewaters Manual;** *U.S. Environmental Protection Agency*, Office of Research and Development, EPA/625/R-99/010, URL <http://www.epa.gov/ordntrnt/ORD/NRMRL/Pubs/2001/wetlands/625r99010.pdf>, November 2001.

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MAP CODE
DTCH

DITCHES

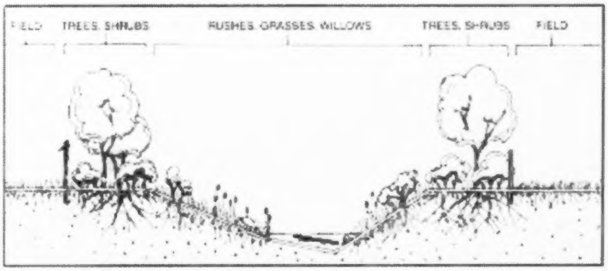
USE
Erosion
Sediment
Stormwater
Site Environmental

What

- Open drainage works ranging from shallow, narrow, frequently dry ditches, to wide, deep, permanently wetted ditches.

Purpose

- To capture and control stormwater and runoff, and to direct it off site. Ditches prevent storm water from collecting silt and can partially filter out potential pollutants, protecting downstream aquatic ecosystems.
- To divert stormwater and runoff around a site.
- To keep work areas as dry as possible, thereby maximizing production and reducing machine and tire wear.
- Also used to direct wash water to sediment ponds to receive treatment for reuse, load application or discharge.



Where

YES: Anywhere stormwater needs to be captured or conveyed. To effectively drain the active site, ditches should be located where stormwater would naturally collect and flow.

NO: Where natural watercourses convey water seasonally or perennially (i.e. do not channel natural watercourses).

Materials Equipment & Costs

- Plants (shrubs, small trees) and grass seeds, geotextiles, gravel or rip rap for armouring, fish barrier.
- Backhoe, equipment operator, labour.
- $ Low to moderate.

Plans & Spec's

Design and Location

- Ditches should be sized to accommodate 110% of peak/storm flows. The sizing should allow for the volume of the vegetation planted in the ditch for erosion control. By providing for this "over-capacity", ditches will function effectively for a longer period and with reduced maintenance requirements and less risk of failure.

- Corners and outfalls should be armoured with rip rap or boulders.
- Ditches should have sufficient grade and capacity to carry the expected run-off, and should be designed and spaced to drain the entire site effectively.
- Permanent ditches should be constructed along the edges of the property; the may not be needed in some dry upland sites.
- With proper design, location and construction, ditches require less maintenance and are more economical over time.
- To minimize the creation of sediment:
  - construct and maintain ditches during dry periods;
  - provide vegetated swales or buffers to filter sediment and pollutants, and
  - provide filter berms or clean-outs to trap mobilized sediment and pollutants.
- Ditches should have barriers to prevent fish from entering and should drain into treatment structures.

Vegetation & Planting

- Planting vegetation and a vegetated buffer strip alongside ditches can be highly beneficial, creating small wind breaks to reduce soil erosion and dust.
- Do not use pesticides close to ditches. A good rule of thumb is to maintain a minimum 10 metres pesticide-free zone along ditches.
- Vegetation growing on the bank of the ditch can help to remove sediment as surface run-off flows through it.

Maintenance

- Regular emptying of clean-outs, especially at culvert inlets and outlets and sediment accumulation areas.
- It is best to work in or near ditches during dry weather.
- Look for areas of the ditch that consistently fill in over time and constrict water flow, usually at an obstruction or a sudden decrease in gradient. Clean out these sections first to see if improvements to water flow are adequate.
- If ditches and sumps are refilling with sediment on a chronic basis, erosion control measures upstream at the operation/site need to be reassessed and improved. Refer to BMPs.
- Check for erosion due to high flow rate.
- Armour as necessary.
- Add check dams if feasible.

Sources

Fisheries and Oceans Canada. ***Ditches, Fish and Fish Habitat.***

United States Department of Agriculture and Mississippi State University. (1999): **Diversion Channel;** in Water Related BMP's in the Landscape/Best Management Practices/Water Runoff Control/D. Water Volume Management/Diversion Channel. *Watershed Science Institute United States Department of Agriculture and Mississippi State University,* <http://abe.msstate.edu/csd/NRCS-BMPs/pdf/water/volume/diversion_chan.pdf>, October 2001.

MAP CODE
DROP

DROP HEIGHT

USE Dust
Noise

What

- Reducing the distance material drops from conveyors and/or loading equipment.

Purpose

- Minimizes and controls the amount of dust released into the atmosphere.
- Decreases noise generated by material impacting truck beds.
- Reduces the risk of operator injury due to the shaking that occurs when a load is dropped into a truck from a great height.

Where

YES: Anywhere front-end loaders, excavators, dump trucks or conveyors drop material into hoppers or stockpiles.

Materials, Equipment & Costs

🚚 None.
⚒ None.
$ Minimal.

Procedures

- Monitor and minimize drop heights from loaders, excavators and conveyors.
- Use conveyors with adjustable heights.
- Locate drop zones behind a protective buffer or building in order to minimize wind velocity which can transport the dust released by the drop.

MAP CODE
SKIRTS

DUST SKIRTS

USE
Dust
Noise

What

- Rubber skirts around aggregate where it drops onto a stockpile or into a truck from a conveyor or hopper.

Purpose

- To contain falling aggregate within a rubber skirt and shield it from exposure to wind, thereby reducing dust emissions, reducing cleanup costs and preventing material segregation.

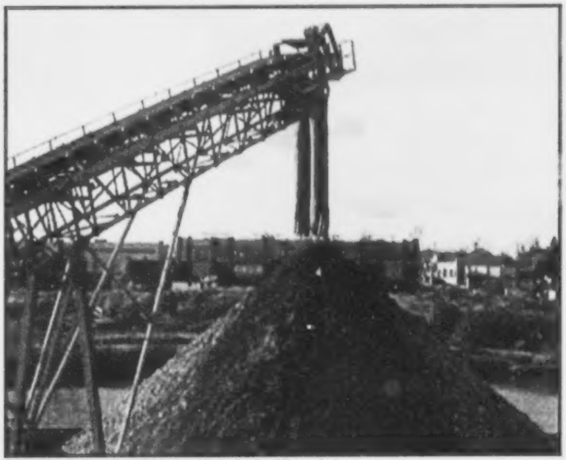


Photo: Sedun (RMX Recycling Ltd., Victoria)

Where

YES: In urban areas where dust emissions are a concern.

Materials Equipment & Costs

- Rubber matting, sheeting or tarps.
- ⚒ Tools for working with skirting material and hanging the skirt.
- $ Variable depending upon skirting used.

Plans & Spec's

- Attach skirt at the end of conveyors or below hoppers.
- The durability and flexibility of rubber matting or sheeting make them effective skirting materials.
- Tarps can also be used, but only temporarily, as the abrasion of aggregate will quickly rip and tear them.
- Serratting the bottom of the skirt will allow it to conform to the shape of stockpiles or loads within trucks.

Maintenance

- Monitor the skirt for effective dust control.
- Inspect the skirt for tears, and repair as needed.

MAP CODE
EWNDW

ENVIRONMENTAL TIMING WINDOWS

USE Site Environmental

What

- A work schedule that does not conflict with critical life stages for fish and wildlife (e.g., spawning and nesting).

Purpose

- To avoid harming fish or wildlife during one of their critical life stage activities.

Source: Alberta Land Conservation and Reclamation Council

Where

YES: During activities that involve blasting, logging, stripping, clearing and grubbing work, especially any work that is done near streams or fish bearing waters. Ideally, work sites should be kept dry. If stormwater discharge is necessary, however, silt laden waters should not be introduced into natural waterways, particularly during sensitive periods for fish.

Materials Equipment & Costs

N/A
⚒ N/A
$ N/A

Plans & Spec's

1. Consult with local Ministry of Water, Land and Air Protection or an "Environmental Atlas" for birds, fish or wildlife in the immediate location of the operation.
2. Contact the appropriate regulatory agency to determine the timing windows for critical life stage activities such as spawning, nesting or birthing.
3. Determine if any proposed activities will likely affect the critical life stages for fish, birds or mammals that live in the vicinity.
4. Sequence activities to avoid impacting those critical life stage activities.

Effects of aggregate activities that impact fish & wildlife

Activity	Side Effect	Affects:
Clearing & Grubbing	Silt	Fish habitat
Clearing & Grubbing	De-forestation	Nesting, calving
Stormwater runoff	Silt	Fish habitat
Erosion	Silt	Fish habitat

- Key activities that should consider life stage activities in their scheduling are:
  - (a) Activities that expose significant amounts of soil;
  - (b) Major activities, such as reclamation works;
  - (c) Activities of lengthy duration.

- A key question to ask of all activities is: what measures should be in place to safeguard fish and wildlife values before the activity begins.

Construction sequence for land clearing with scheduling considerations to reduce silt from entering natural watercourses and fish habitat.

Activity	Schedule Consideration
1. Constructing initial access: entrance, on-site routes, equipment parking areas.	**First land-disturbing activity:** stabilize bare soil areas immediately with gravel and temporary vegetation as excavation takes place.
2. Installing sediment traps and barriers: sediment fences, straw bale barriers and outlet protection.	**Install principal basins after mine site is accessed:** install additional traps and barriers as needed during excavating.
3. Installing ditches & runoff control: ditches, water bars, check dams, inlet and outlet protection, slope drains.	**Install key control measures after principal sediment traps and before excavating:** install additional runoff-control measures during excavating.
4. Land clearing and grading: site preparation - cutting, filling and grading, sediment basins, barriers, diversions, drains, surface roughening.	**Begin major clearing and excavating after principal sediment and key runoff-control measures are installed:** clear borrow and disposal areas only as needed. Install additional control measures as excavation progresses. Mark trees and buffer areas for preservation.

- In planning clearing and grubbing work, it may be helpful to outline the sequence of activities and list any erosion control and sediment traps that should be in place before the next stage of the clearing begins. This list can provide a logical order to schedule work.
- Schedules will vary due to weather and other unpredictable factors.

Installation

- Site access is normally the first land-disturbing activity. Exercise care not to damage valuable trees or disturb designated buffer zones.
- Install principal sediment basins before any major site clearing and grubbing takes place. Erect additional sediment traps and sediment fences to keep sediment contained on-site at appropriate locations.

- Locate key runoff-control measures to divert water from planned undisturbed areas out of the traps and sediment-laden water into the settling ponds or sediment basins.
- Install diversions above areas to be disturbed prior to work and install additional runoff-control measures as work takes place.
- Install the main ditches with inlet and outlet protection devices early, and use them to convey storm runoff through the site.

Typical stabilization considerations for a general aggregate development sequence

Aggregate Development Activity	Schedule Consideration
1. Pre-development surface stabilization: temporary and permanent seeding, mulching, sodding, riprap.	Apply temporary or permanent stabilization measures immediately on the disturbed areas where work is delayed or complete.
2. Development: buildings, utilities, paving.	Install necessary erosion and sedimentation control practices as work takes place.
3. Landscaping and final stabilization: topsoiling, trees and shrubs, permanent seeding, mulching, sodding, riprap.	Last phase - Stabilize all open areas, including borrow and spoil areas. Remove and stabilize all temporary control measures.

Maintenance

- Follow the schedule. When changes in mining activities are needed, amend the schedule in advance to maintain environmental timeframe control.
- Following a work timeframe should help keep field personnel aware of the environment around them. Orderly modification assures coordination of work targets while ensuring basic needs of wildlife and the environment are met.

Sources

United States Department of Agriculture. (1994): **Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater, Best Management Practice Standards.**

British Columbia Ministry of Water, Land and Air Protection. (2001): **Environmental Objectives, Best Management Practices and Requirements for Land Developments;** BC Environment, Vancouver Island Region, URL <http://wlapwww.gov.bc.ca/vir/pa/bmp_dev1.htm>, October 2001.

MAP CODE
EQUIP

EQUIPMENT SELECTION

USE
Dust
Noise
Emergency
Spill Response

What

☛ Selecting equipment based on its energy consumption, noise output, exhaust configuration, compatibility with other equipment on site, and compatibility with approved mine plan.

Purpose

☛ To reduce energy consumption, noise and dust emissions, and the costs of replacement parts for each piece of equipment purchased.

OR

Where

YES: All fixed and mobile plants.

Materials Equipment & Costs

☛ N/A
⚒ N/A
$ Varies. Equipment with noise and dust control options may increase costs.

Plans & Spec's

- Consider drive-by noise.
- Consider upswept exhaust. Exhaust directed to the ground can create dust.
- Can the direction of the exhaust be rotated so that during peak outputs, such as power lifting from a stockpile, the noise of the exhaust is directed away from a neighbour?
- Is the equipment designed for ease of capture and proper disposal of used fluids and waste materials such as oils, coolants, filters, batteries and tires?
- Select equipment that produces low levels of emissions. Some advanced engines are able to produce greater torque at lower revolutions per minute (RPMs) than conventional engines, while creating fewer emissions.
- Where applicable, use biodegradable hydraulic fluids. These products are comparable to conventional oils in price, use the same seals and filters, are non-toxic, and can mix with mineral oil to allow for changes in the field.
- Does the equipment come with its own spill kit?
- Does the loader capacity match truck capacity?

- Does the loader (crusher, wash plant, etc.) have the necessary capacity to meet production goals within the hours of operation allowed by the local government?
- Does the wash plant recover all saleable material in order to reduce sediment going to the settling pond?
- Does an excavator provide greater reach to permit higher benches?
- Would larger trucks result in fewer trips to reduce traffic impacts?
- Would smaller trucks result in less noise, dust and vibration generation?

Maintenance

- Establish a regular maintenance schedule according to manufacturer's guidelines.

MAP CODE
ECB

EROSION CONTROL BLANKET

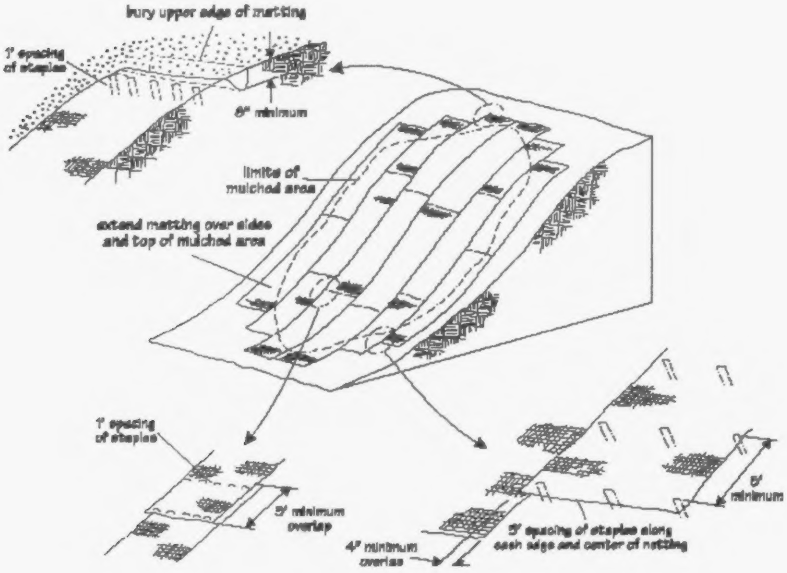
USE
Erosion
Sediment
Stormwater

What

- A temporary protective blanket laid on top of bare soil vulnerable to erosion, commonly made of mulch, wood fibre or synthetics.

Purpose

- Placed onto prepared, seeded soils to prevent washing away of the seed and erosion of the prepared seedbed. After the vegetation grows, the blanket degrades over time until only the vegetation is left in place. Once established, the vegetation provides permanent erosion control.
- Can be used on steep slopes where severe erosion control problems are anticipated.


bury upper edge of matting
1' spacing of staples
6" minimum
limits of mulched area
extend matting over sides and top of mulched area
1' spacing of staples
5' minimum overlap
5' minimum
5' spacing of staples along each edge and center of netting
4" minimum overlap

Source: Idaho Department of Lands, 1992.

Erosion Control Blanket Installation

Where

YES: Erosion control blankets are superior to hydroseeding when the growing season is short and plants cannot stabilize the slope quickly, when at high altitudes or where major storms are a frequent occurrence.

Materials Equipment & Costs

Mulch, wood fibre, synthetics or combinations, and staples, stakes or anchors.

⚒ Hand tools, labour.

$ Medium to high.

Plans & Spec's

- Applying erosion control blankets over large areas can be prohibitively expensive. However, small applications in areas that are especially steep and/or prone to erosion can be very effective in conjunction with cheaper methods such as hydro-mulching and/or hay mulch and netting.
- The effectiveness of jute netting and mulch fabrics is greatly reduced if rills and gullies form beneath these fabrics. Therefore, proper anchoring and ground preparation are essential.
- To further control the amount of stormwater that may flow over an area, consider installing a diversion ditch at the top of the slope.

Installation

- Care should be taken to anchor edges (particularly on the up-slope side) and overlap joining sections to ensure adequate protection.
- Follow manufacturer's instructions.

Maintenance

- Close inspection after storms and major runoff occurrences is essential, as erosion control blankets will often mask slope failures from all but the closest scrutiny until erosion is so far along that the slope can no logner be effectively treated with spot methods.

Sources

United States Department of Agriculture and Mississippi State University. (1999): **Erosion Control Blanket;** *in* Water Related BMP's in the Landscape/Best Management Practices/Water Runoff Control/C. Erosion Control. *Watershed Science Institute United States Department of Agriculture and Mississippi State University*, <http://abe.msstate.edu/csd/NRCS-BMPs/contents.html>, October 2001.

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MAP CODE
FENC

FENCES

USE
Dust
Noise
Risk Management
Visual

What

- A man-made or natural barrier.

Purpose

- Can reduce the amount of noise and dust leaving the site, create a visual barrier, and prevent trespassing.
- To protect trespassers or livestock from potential hazards within an aggregate site by physically preventing or hindering entry.
- To minimize liability in the event of injury or death as a result of unauthorized entry.

Where

YES: Around the perimeter of the aggregate operation (for security), at any point on the perimeter (to prevent dust or noise from reaching off-site receptors), at any sight line between the mine and off-site receptors (as a visual barrier), between any loud mining activity (i.e., crushing) and any possible receptor, or beside or around a dust-generating activity.

NO: There may be some limitation to the use of fences as a means of preventing trespass in areas with heavy snowfall.

Materials Equipment & Costs

- 18 guage steel, chain link, barbed wire, pre-cast concrete, rock, hedges, fence stakes or posts, staples, nails or wire, etc.
- 🛠 Dependent on type and function of the fence.
- $ Low to high depending on height, materials and design.

Plans & Spec's

Noise

- There are many fencing options available to block or minimize noise (e.g., chain link, 18 gauge steel, barbed wire, pre-cast concrete, rock).
- To be effective, the fence needs to be high enough to block the noise generating activity from the line of sight of any receptor, and long enough to prevent noise from "leaking" around the ends.
- Used conveyor belts hung on a sturdy frame have long been used as a very effective noise barrier/fence.

- Fencing materials should be either flexible enough to absorb noise, or rigid enough to reflect it.

Dust

- Solid fences and vegetative screens have both been found to be effective.
- A vegetative screen has the advantages of enhancing the appearance of the mine, and requiring no maintenance once established.
- Existing vegetation can be used as a screen by locating dust generating activities, such as a haul road, on the down wind side of the vegetation.

Risk Management

- Barbed wire is the most cost effective fencing for detering unauthorized entry.
- Construct the fence high enough that it cannot be easily scaled, and string the wire in loose double loops for entanglement.
- Post signs every 15 to 30 metres, and ensure that at least one sign is visible from any position at the fence. See also Signage BMP.

Visual

- A thick screen of trees and native vegetation is a visually appealing fence and has the added ability to screen noise and dust.
- Position the screen or fence between on-site features such as workings, equipment, buildings or the excavation face, and any off-site receptors.

Options

Maintenance

- Regular inspections should be conducted, particularly before and after hunting seasons. Repair or replace damaged or missing signs.
- Dependent on the type of fence. Solid wood fences may require powerwashing on a regular basis as dust or dirt accumulates.

Sources

Mah, K.L. (1987): **Security and Safety of Aggregate Pits;** *Alberta Transportation,* Aggregate Services, Materials Engineering Branch, Aggregates Bulletin #6.

MAP CODE
FDRN

FRENCH DRAINS

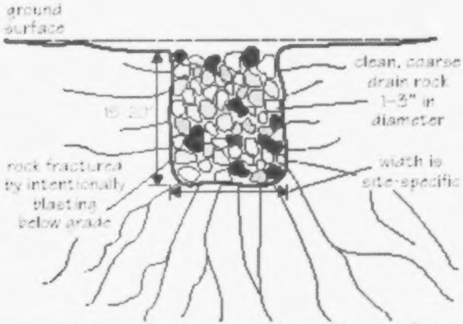
USE Stormwater

What

- A hole or trench filled with coarse aggregate. Also called a Dry Well.

Purpose

- To hold collected water until it percolates into the ground.


ground surface
clean, coarse drain rock 1-3" in diameter
15'-20'
rock fractured by intentionally blasting below grade
width is site-specific

Source: Washington State Department of Natural Resources, Oregon Department of Geology and Mineral Industries.

Details French Drain construction.

Where

YES: Wherever stormwater cannot be drained off (e.g., around buildings), volumes are small, or natural infiltration is poor.

Materials, Equipment & Costs

- Coarse aggregate, filter fabric, optional blasting explosives to fracture quarry rock.
- Backhoe or excavator, hand shovel, labour.
- $ Low.

Plans & Specs

- Flatter areas are preferable.
- Because there is no outlet for water, French drains should be located where stormwater will naturally accumulate.
- Ditches and grading can also be used to direct stormwater runoff to the French drains.
- French drains should not be used where oil and grease are present to contaminate the ground water.

Installation

- Excavate a hole or trench to the maximum reach of the equipment used: the deeper the better.

- Line the excavation with filter fabric. For lining the walls, drape the filter fabric over the edge while backfilling. It can be secured by holding the top in place prior to draping it into the hole, by stapling it to the walls, or with boards fastened to the walls.
- Fill the bottom of the well with clean and washed pea gravel to form the base. Clean coarse aggregate can be used to fill the excavation to within 15 cm of the top. Cap the excavation with a 15 cm layer of pea gravel to act as a filter.
- Percolation rates should not be less than 15 cm per hour and can be tested the same way as septic fields.
- To avoid compacting the subsoil, use equipment with tracks or oversized tires.

Maintenance

- Maintenance is typically limited to periodic replacement of the fill with clean rock.
- Periodic inspection is required to ensure that the stone fill is level to the ground surface and that the filter fabric, if used, has not become clogged with material.
- A larger well will function for a longer period before requiring maintenance.

Sources

United States Department of Agriculture and Mississippi State University. (1999): **Dry Well**; *in* Water Related BMP's in the Landscape/Best Management Practices/Water Runoff Control/D. Water Volume Management,. *Watershed Science Institute United States Department of Agriculture and Mississippi State University*, <http://abe.msstate.edu/csd/NRCS-BMPs/contents.html>, October 2001.

Norman, D.K., Wampler, P.J., Throop, A.H., Schnitzer, E.F. and Roloff, J.M. (1997): **Best Management Practices for Reclaiming Surface Mines in Washington and Oregon;** *Washington State Department of Natural Resources* Open File Report 96-2 and *Oregon Department of Geology and Mineral Industries* Open File Report O-96-2, page 2-20, URL <http://www.wa.gov/dnr/htdocs/ger/pdf/bmp.pdf> [PDF, 7.6Mb], June 2001.

MAP CODE
GRDG

GRADING

USE
Erosion
Sediment
Stormwater

What

- Reshaping the ground surface to prepare the site for processing equipment, stock pile areas, etc., and for post extraction reclamation.

Purpose

- To provide suitable topography for post-mining land uses.
- To facilitate equipment operation and stockpiling.
- To control surface runoff.
- To minimize soil erosion and sedimentation both during and after development of the site or aggregate extraction.

Source: City of Los Angeles

Where

YES: Wherever re-contouring is necessary for operational activities, site development, operation of sediment control practices, stockpiling, or to achieve land forms required for reclamation.

Materials Equipment & Costs

None.
Grader, scraper, or bulldozer with blade.
$ Low.

Plans & Spec's

- Careful shaping of an aggregate site for operations and for post-reclamation activities reduces the potential for erosion and the cost of installing erosion and sediment control measures.
- Before grading begins, decisions must be made on the steepness of cut-and-fill slopes and how they will be protected from runoff, stabilized and maintained. A

grading plan can establish drainage areas, direct drainage patterns and affect runoff velocities.

- A grading plan can form the basis of an erosion and sediment control plan. Key considerations that affect erosion and sediment control include deciding which slopes are to be graded, when the work will start and stop, the slope angle, the length of finished grades, where and how excess material will be stored or disposed of, and where borrow material will be needed. Early completion of grading work allows for prompt topsoiling and vegetation for erosion control and eliminates temporary seeding expense.
- Undisturbed temporary and permanent buffer zones may provide an effective and low-cost erosion control measure for adjacent grading work.
- Intercept and redirect stormwater to avoid flows on newly graded slopes.
- Use slope breaks, such as diversions or benches, as appropriate, to reduce the length of a cut or fill slope, limit sheet and rill erosion and prevent gullying. A spacing guide is shown below.

Spacing guide for slope breaks

	Slope *	**Slope Break Spacing (metres)**
Steep Slopes	2:1 (50%)	6.0
	3:1 (33%)	11.0
	4:1 (25%)	14.0
Long Slopes	15-25%	15.0
	10-15%	24.0
	6-10%	38.0
	3-6%	61.0
* *100% slope* = 1:1 = 45°	<3%	91.0

- Stabilize all graded areas with hydroseeding, vegetation, crushed stone, riprap or other appropriate ground cover as soon as grading is completed. Use mulch or straw to temporarily stabilize areas where final grading must be delayed.
- For grass and legume cover, finished slopes should not be steeper than 2:1. Slopes to be maintained by tractor or other equipment should not be steeper than 3:1.
- Roughen the surface of all slopes during the grading to retain water, increase infiltration and facilitate vegetation. Running a tracked vehicle up and down the slope leaves divots perpendicular to the slope length that can roughen the hill slope. Do not drive the tracked vehicle across the contour of the slope, as that will leave divots that channel water down slope.
- In areas with high water tables, install underground drainage to prevent seepage, and thus keep the surface dry.

- Fill should not be placed adjacent to a channel bank, where it can create bank instability and failure, or result in deposition of sediment downstream. Also avoid placing fill in places where it will block or limit natural flooding.
- Provide stable channels and floodways to convey all runoff from the developed area to an adequate outlet without causing increased erosion or off-site sedimentation.

Installation

- Construct and maintain all erosion and sediment control practices and measures in accordance with sediment control planning.
- Timing of grading should account for the conditions for revegetating the site after the machine work is completed. For example, grading should not be done during an extreme rainfall event.
- Scarify the surface to a minimum depth of 8 centimetres before placing topsoil.
- Excessively compacted areas should be thoroughly ripped/subsoiled to facilitate drainage and root growth.
- Keep diversions and other water conveyance measures free of sediment until other vegetation is established.
- Permanently stabilize all graded areas immediately after final grading is completed.

Maintenance

- Periodically check all graded areas and supporting erosion and sediment control measures, especially after heavy rainfalls.
- Remove excess sediment from diversions and other water-disposal structures.
- If washouts or breaks occur, repair them immediately.

Sources

National Conference on Urban Runoff Management (1993): **Training for Construction Site Erosion Control and Stormwater Facility Inspection;** Enhancing Urban Watershed Management at the Local, County and State Levels.

MAP CODE
ROAD

HAUL ROADS

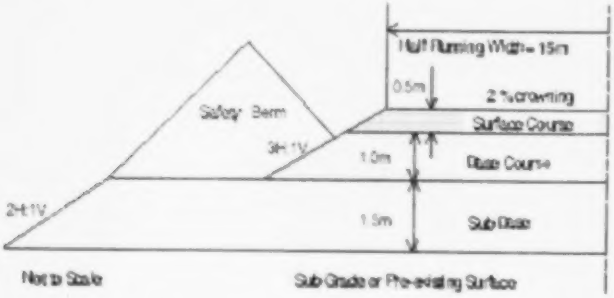
USE
- Dust
- Noise
- Sediment
- Stormwater

What

- System of roads within an aggregate mining operation.

Purpose

- To facilitate safe and efficient operation of mobile equipment while minimizing environmental impacts.
- When well-designed and constructed, haul roads can make the aggregate operation safer, more productive, and cause less wear and tear on equipment.


Half Running Width = 15m
0.5m
2 % crowning
Safety Berm
Surface Course
3H:1V
1.0m
Base Course
2H:1V
1.5m
Sub Base
Not to Scale
Sub Grade or Pre-existing Surface

Typical haul road cross-section.

Source: University of Alberta

Where

YES: All aggregate operations.

Materials Equipment & Costs

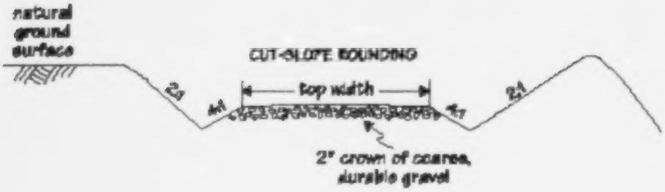
⊸ Mine waste, gravel, overburden, crushed stone, asphalt or concrete.

⚒ Bulldozer, excavator, scraper, dump truck.

$ Varies.

Plans & Spec's

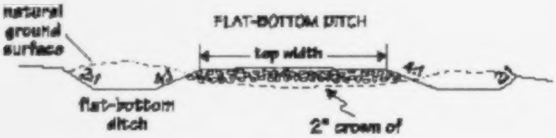
- Keep frequently used haul roads and other heavy traffic areas dry by elevating the surface to facilitate runoff.
- Dryer roads cause less wear and tear on tires and equipment and create less sediment-laden water that will require treatment.
- Make sure roads are well capped with durable rock of appropriate size.
- Road widths are usually designed to be 3 times the width of the largest haul truck (for 2 way traffic) with extra width employed on the curves. (Refer to HSRC 6.8)
- Road shoulder barriers/berms should be ¾ of the height of the largest tire on any vehicle hauling on the road.


natural
ground
surface
CUT-SLOPE ROUNDING
top width
2:1
4:1
4:1
2:1
2" crown of coarse,
durable gravel

Profile of elevated haul road on side hill.

Source: Washington State Department of Natural Resources, Oregon Department of Geology and Mineral Industries

- Banking of curves (super-elevations) and their transitions are designed to minimize the centrifugal forces on the haul truck while negotiating the curve. Super-elevations should be in the range of 4% to 6%, depending on the curve radius and equipment speed.
- In the design of both horizontal and vertical curves, line-of-sight and stopping distance are key criteria. Design curves so that the line-of-sight of the driver is equal to or longer than the stopping distance of the loaded haul truck.


natural
ground
surface
FLAT-BOTTOM DITCH
top width
2:1
4:1
4:1
2:1
flat-bottom
ditch
2" crown of

Profile of elevated haul road on flat ground.

Source: Washington State Department of Natural Resources, Oregon Department of Geology and Mineral Industries

- Grades usually vary from -20% to +20%. Grades over 10%, however, are used only for short distances in temporary situations. The preferred maximum grade is usually 8%.
- Sharp horizontal curves should not be designed at the top or bottom of hills.
- Intersections should be located at flat, straight alignments of the haul road.
- Road surface cross-slopes should be approximately 1:25 (4%) for good drainage.
- Curve radii should always exceed the minimum turning radius of the equipment.
- Provide runaway lanes for grades in excess of 5%.

ECONOMICS

When considering the quality of the road to construct, the most important items are:

- Life of road
- Use of road (amount of production over the road)
- Location of road (is it permanent or does it have to be removed?)

Classification of Haul Roads by lifespan

Temporary Roads	• short life • minimum thickness • low specification material • inexpensive to build • used mainly for shovel or dump access
Semi-Permanent Roads	• medium life • engineered to desired thickness • high specification material • relatively expensive to build • used for main haul roads in pits and out-of-pit hauls in non-final pit walls
Permanent Haul Roads	• long life • engineered to ultimate thickness • high specification material (may even be paved) • expensive to build • used for final out-of-pit haul roads.

DESIGN

- A haul road consists of four distinct layers:

  Sub-grade

  Sub-grade made of hard, sound rock or dense, compact gravel, may not require fill as haul trucks can travel on the sub-grade surface. If the sub-grade lacks the required bearing capacity, then it needs to be altered through suitable measures such as compaction.

  Sub-base

  Run of mine and coarse rock usually make up this layer. The sub-base provides structural strength to the road and can also prevent intrusion of the sub-grade soil into the base course and vice-versa, minimizing the effect of frost and accumulation of water in the road structure.

  Base course

  Usually high quality material with suitable size fractions is used for the construction of this layer. As the base course is the main source of the structural strength of the road, specifications of strength, plasticity and gradation are generally more stringent than for the other layers.

  Surface

  Generally constructed with appropriately sized gravel closely controlled grading to avoid dust problems while maintaining the binding characteristics of the material. Apart from providing a smooth riding surface, it distributes the load over a larger area, thus reducing stress.

Maintenance

- Establish a regular grading program that will minimize erosion, sediment build-up, noise and dust.
- Ensure that potholes, washboarding and frost heaving are repaired immediately to minimize noise, dust and equipment wear.

- Spray water, calcium chloride or other approved dust suppressant on the road surface.
- Roads may also require scarifying, sanding and resurfacing.

Sources

Ministry of Employment and Investment. (1997): **Health, Safety and Reclamation Code for Mines in British Columbia** Section 6.8.

British Columbia Ministry of Energy and Mines. (1997): **Health, Safety and Reclamation Code for Mines in British Columbia** Section 6-8; Mines Branch, URL <http://www.em.gov.bc.ca/Mining/Healsafe/hsrecode1.htm>, October 2001.

Tannant, D. and Regensburg, B. (2000): **Guidelines for Mine Haul Road Design;** *University of Alberta, School of Mining and Petroleum Engineering.*

Norman, D.K., Wampler, P.J., Throop, A.H., Schnitzer, E.F. and Roloff, J.M. (1997): **Best Management Practices for Reclaiming Surface Mines in Washington and Oregon;** *Washington State Department of Natural Resources* Open File Report 96-2 and *Oregon Department of Geology and Mineral Industries* Open File Report O-96-2, page 2-18 to 2-19, URL <http://www.wa.gov/dnr/htdocs/ger/pdf/bmp.pdf> [PDF, 7.6Mb], June 2001.

MAP CODE
LIGHT

LIGHTING MANAGEMENT

USE
Landscape
Risk Management
Safety

What

☛ The planning and installation of a lighting system that facilitates safe and secure operations, while minimizing offsite visual nuisance.

Purpose

☛ To help ensure a safe working environment, extend hours of operation, illuminate on-site hazards for staff and visitors, and provide security to the site after hours.

Where

YES: Entrance/exit, work faces, haul roads, stockpiles, buildings, equipment, vehicles.
NO : Wherever it may spill, glare or reflect off-site.

Materials Equipment & Costs

⚷ Worklights, headlights, back-up lights, signals, spotlights, warning lights, hazardous area lighting, emergency lights, floodlights, wiring, fixtures.
⚒ Electrician and appropriate wire and tools, equipment necessary for raising poles or light standards, labour.
$ Low to medium.

Plans & Spec's

- Where lighting is installed, ensure that it is directed downward to minimize off-site spill and glare. Balance safety and security with concerns of neighbours.
- Lights positioned so that they are shielded by buildings or permanent plant facilities may be less visible from the surrounding countryside and pose less of an annoyance to neighbours.
- Lighting is often installed for security and risk management purposes.
- Mount lighting below the roof height of buildings and perimeter fencing and direct the light downwards.
- Keep lighting of road junctions and site entrances to the minimum required for safety purposes.

- Light poles, stands and columns will blend in with the surrounding landscape if painted a similar colour (e.g., a dark colour if the light poles are set against a backdrop of vegetation). Trees and hedgerows may also help to 'contain' the light.

Maintenance

- Regular inspection is required to ensure burned out tubes and bulbs are replaced and broken fixtures are repaired.

Sources

Cole, L., Smith, P., Wright, J. and Clough, R. (1999): **Controlling the Environmental Effects of Recycled and Secondary Production Good Practice Guidance;** *United Kingdom Department of the Environment, Transportation and the Regions*, URL <http://www.planning.detr.gov.uk/recycled/practice/index.htm>, June 2001.

MAP CODE
MCOR

MATERIAL CORRALS

USE Erosion
Stormwater

What ☛ Three-sided storage bays made from interlocking pre-cast concrete blocks.

Purpose ☛ To keep specialized products and material clean and segregated, especially at tight locations.

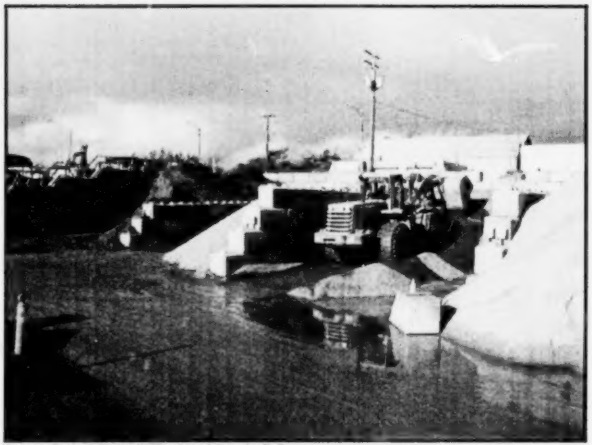


Photo: Sedun, RMX Recycling, Victoria B.C.

Where **YES:** In areas of limited space, and where product purity specifications are strict.

Materials Equipment & Costs

- Pre-cast concrete blocks.
- ⚒ Excavator or front-end loaders, broom, pry bars.
- $ Depends on size of corral and price of blocks.

Plans & Spec's

- Follow manufacturer's specifications and instructions for design and installation of walls.
- Pre-cast concrete block walls require a solid, level foundation, with approximately 15 centimetre of granular material for drainage.
- Rolled filter cloth placed between blocks will help stop fine-grained products from migrating through the corral walls.
- Poured concrete floors or pre-cast concrete slabs can protect products from contamination by surface materials.

- Camber (arch) the corral floor to facilitate drainage. In exceptionally wet areas, stormwater drainage pipes may have to be laid adjacent to corral walls.
- Walls of three to four layers of blocks are usually sufficient. For higher walls, a qualified engineer should be consulted.
- If backfilling behind the back wall, install sufficient drainage pipe surrounded by drain rock.

Installation

- Prepare the site by levelling the area, cambering the corral floor, compacting any fill material, and preparing any drainage trenches that will not be accessible after construction of the walls.
- Prepare a level and compacted gravel base for the first layer of blocks.
- Lay down four to six base layer blocks.
- Sweep the top of each layer before subsequent layers are laid.
- Place rolled-up filter fabric between blocks on all sides. Duct tape can be used to hold the filter fabric during assembly.
- Lay the second and subsequent layers in a staggered manner, to ensure they fit.

Maintenance

- Inspect for material migrating through wall.
- Where excessive settling has occurred, sections of the wall may have to be re-laid.
- Pressure wash and apply surface treatments as required (algae growth, changed product, etc.).

Sources:

United Lock-Block™ Ltd. URL <http://unitedlockblock.com/>, August 2001.

MAP CODE
O/WSP

OIL/WATER SEPARATORS

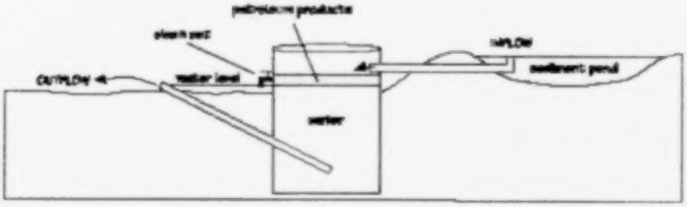
USE
- Emergency Spill
- Risk Management
- Stormwater
- Waste

What

- A pond or tank that separates petroleum products from water using the difference in liquid density.

Purpose

- To remove petroleum products prior to release or reuse of water.



Source: WSDNR, ODGMI

This system uses a clean-out spigot to remove the oil as it floats atop the water.

Where

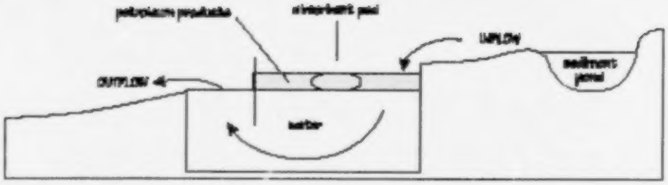
YES: Anywhere hydrocarbon-contaminated water can be collected, or prior to release into the environment.

Materials Equipment & Costs

- A concrete or metal tank set up as an oil/water separator.
- Equipment to move tank, hand tools to install, labour.
- $ Moderate to high.

Plans & Spec's

- Size and type will not be the same for every operation.
- As a rule of thumb, the tank or collection area should have at least 1.85 square metres of surface area per 1000 square metres of drainage area to allow the petroleum to remain on the surface,.
- The water velocity and volume must be low enough to prevent oil/water mixing or overspillage.
- The majority of settleable solids must be removed from the stormwater stream before it reaches the oil/water separator or the separator will quickly become filled with sediment.



Source: WSDNR, ODGMI

This system uses an absorbent pad to soak up the oil.

Maintenance

- Scheduled maintenance should be performed to provide for periodic removal of debris and to ensure that the devices are operating efficiently.
- Surface facilities should undergo a drive-by inspection at least weekly and after any rain totalling 13 millimetres or more in 24 hours.
- Oil and solids should be removed frequently, including at the beginning and end of the main runoff season. The waste must be disposed of as specified by regulations.
- The effluent shutoff valve should be operational for closure during cleaning.

Sources

Chilibeck, B., Chislett, G. and Norris, G. (1992): **Land Development Guidelines for the Protection of Aquatic Habitat;** *Department of Fisheries and Oceans,* and *Ministry of Environment, Lands and Parks,* URL <http://www-heb.pac.dfo-mpo.gc.ca/english/publications/PDF/guidelines/ldg.PDF>, June 2001.

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MAP CODE
OUTLT

OUTLET PROTECTION

USE Erosion
Sediment

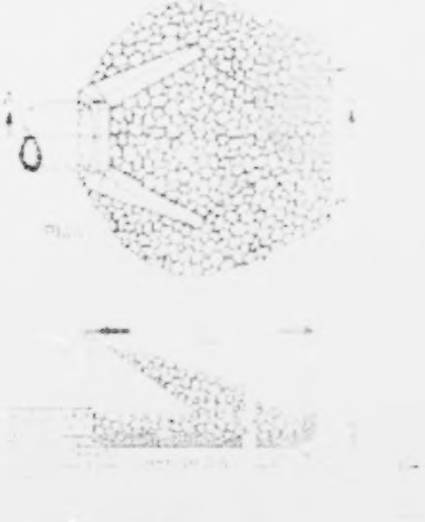
What

- A rock lined apron and flow area at the outlet of a pipe or culvert, paved flume, lined waterway or other flow system.

Purpose

- Prevents scour and erosion at water conveyance outlets.
- Minimizes the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Pipe Outlet to Well-Defined Channel



Notes:

1. L_a is the length of the riprap apron.
2. d=1.5 times the maximum stone diameter but not less than 6".
3. In a well-defined channel, extend the apron up the channel banks to an elevation of 6" above the maximum tailwater depth or to the top of the bank, whichever is less.
4. A filter blanket or filter fabric should be installed between the riprap and soil foundation.

Source: USDA-NRCS, 2001

Where

YES: Outlet protection is required at the outlets of all ponds, stormwater systems, pipes, culverts, ditches and anywhere runoff is conveyed to a natural or manmade drainage feature such as a stream wetland, lake or ditch.

Materials Equipment & Costs

- Riprap, filter fabric.
- ✕ Equipment to move materials.
- $ Low.

Plans & Spec's

- Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on undisturbed soil may also be filled by increasing the riprap thickness.
- The minimum thickness of the riprap should be 1.5 times the maximum stone diameter.
- Construct the apron with no overfall at the end. Make the top of the riprap at the downstream end level with the receiving area or slightly below it.
- Immediately after construction, stabilize all disturbed areas with hydroseeding or any other proven method.

Installation

- Use the 10 year peak runoff or the design discharge of the water conveyance structure (whichever is greater) to size the outlet production.
- With low flows, vegetation, including sod, can be effective.
- If the water discharges directly into a well-defined channel, extend the apron across the channel bottom and up the channel banks to an elevation of 15 centimetres.

Maintenance

- Inspect riprap outlet structures after heavy rains to see if any erosion has taken place around or below the riprap, or if stones have been dislodged.
- Add rock as needed to maintain the intended function.
- Immediately make all needed repairs to prevent further damage.

Sources

Austin, L. (2001): **Construction Stormwater Pollution Prevention;** Stormwater Management Manual for Western Washington, Volume II. *Washington State Department of Ecology*, page 129, Publication 9912, URL <http://www.ecy.wa.gov/biblio/9912.html>, June 2001.

United States Department of Agriculture, (1994): **Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater, Best Management Practice Standards.**

MAP CODE
PPREV

Pollution Prevention

USE

Emergency Spills
Stormwater
Waste
Site Environmental

What

☛ Any structure, practice or method used to manage potential pollutants that are used or stored at an aggregate operation.

Purpose

☛ To prevent or minimize contamination of stormwater and groundwater by protecting and containing chemicals and petroleum products.

Where

YES: Wherever potential pollutants are handled or stored, such as at refuelling depots, maintenance sheds and shops.

NO : Covered containment is not necessary for benign materials storage (i.e., materials that are not considered pollutants).

Materials, Equipment & Costs

☛ Concrete or other impervious floor, a suitable structure of lumber, plywood, roofing tiles or galvanized metal, metal shipping containers, tarpaper, concrete, polyvinyl, tanks, drums, barrels, lube cubes, absorbants (such as polypropylene, sawdust, paper, corn cob, zeolites, vermiculite or clay granules), goggles, nitrile gloves, disposal bags.

⚒ Drum dolly, spill kits, labour and hand tools.

$ Low to moderate.

Plans & Specs

Covered Containment

- Covered containment is any permanent or portable shed/structure which protects the potential pollutants from rain, and prevents spills from percolating into the ground.
- The size, type and duration of containment will dependon the amount of material in storage, and handling requirements (drums, etc.).
- For a permanent structure, a berm or footing should be constructed around the perimeter of the storage area. It can be a simple concrete foundation where the structure is walled, or an impermeable berm in the case of an open or carport type of containment area.

- Large steel shipping containers are often used as portable self contained lockable covered contaiment sheds. These containers can be relocated around the aggregate site as operations shift from one area to another.

Impervious Containment

- Impervious containment is meant to prevent spilled fluids from seeping into the soil or flowing into surface water courses.
- These berms and impervious surfaces should be located in areas such as fueling stations, where minor spills happen frequently.
- Ensure that the berm is large enough to contain all of the storage containers and material transfer activities (such as fueling), plus ten percent.

Drum Handling

- Any flammable or combustible liquid should only be stored in containers specifically designed for them.
- Drums should be moved by drum dolly, and not rolled.
- Containers of 23 litres or less should be stored in an equipment box whenever being moved by vehicle.

Spill Kit

- A spill kit should contain all of the equipment and supplies necessary to clean up spills of fuels or other contaminants before they spread or cause further damage.
- Locate emergency spill containment and cleanup kits in high potential spill areas. The contents of the kit should be appropriate for the type and quantity of potential contaminants stored at the facility. Carry kits on mobile equipment, diesel power plants and trucks.
- Disposal of used kits and recovered spill material should be carried out according to manufacturer's instructions and Provincial regulations regarding contaminants.

Maintenance

- Ensure the roof or tarp does not leak, that the floor is cleaned regularly and that any cracks are repaired promptly.
- Plastic containers designated to carry petroleum products should not be more than 5 years old.
- Waste oil and solvents are usually considered to be special waste, and should be stored in a secondary containment. For disposal options for these materials, contact a regional Ministry of Water, Land and Air Protection office.

Sources

Aggregate Producers Association of Ontario. (1999): **Environmental Management Guide for Ontario Pits and Quarries**, Version 2.0.

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Ciuba, S. (2001): **Source Control BMPs;** Stormwater Management Manual for Western Washington, Volume IV. *Washington State Department of Ecology*, Publication 9914, URL < http://www.ecy.wa.gov/biblio/9914.html>, June 2001.

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MAP CODE
RBSN

RETENTION BASIN

USE
Environment
Pollution
Prevention
Siltation
Stormwater

What

- A pond to hold stormwater and filter out sediment.

Purpose

- To retain stormwater runoff and to remove the majority of the sediment within the stormwater, by settling.
- Not a settling pond for wash plant water.

Source: Center for Sustainable Design, Mississippi State University, 1999

Where

YES: In a low area or natural drainage way. Basins should be located where stormwater naturally flows or collects.

NO: Should not be constructed on streams or where failure can endanger fish habitat, human safety or property.

Materials, Equipment & Costs

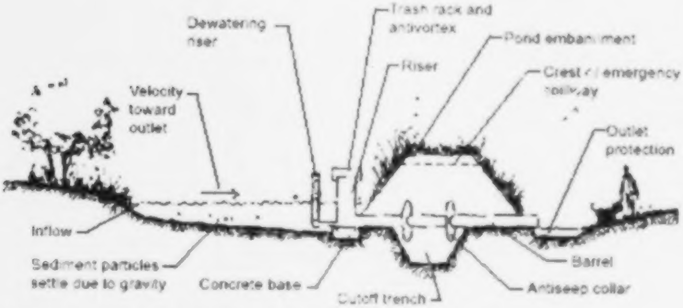
- Earth, riprap, pipe, collars, seed for stabilization of disturbed soil.
- ⚒ Backhoe, labour.
- $ Variable depending upon size and design.

Plans & Specs

- Sediment basins are at best only 70-80 percent effective in trapping sediment which flows into them. Therefore, they should be used with other erosion control practices such as temporary seeding, mulching, diversion dikes, etc., to reduce the amount of sediment before it gets to the basin.

Plans & Spec's cont'd

- The basin should be located to intercept the largest possible amount of runoff from the site. The best locations are generally low areas and natural drainage ways.
- Drainage into the basin can be improved by diversion dikes and ditches.
- Retention basins can be made with a number of designs, including:
    1. Simple dugout
    2. Embankment pond
- Contact the local Mines Branch Regional office for specific Health, Safety & Reclamation Code requirements and the local office of the Ministry of Sustainable Resource Management for environmental regulations related to larger retention basins.
    - There are a number of formulae for calculating the optimum size for stormwater retention basins, but they are beyond the scope of this handbook. Operators can obtain technical advice on these calculations from the above agencies.
    - A common approach is to construct a number of ponds in series, with the first to take out the coarsest material, and subsequent ponds to capture progressively finer suspended solids. A series of ponds allows one or more ponds to operate while another is being cleaned.
- A suggested maximum drainage area for a single basin is 10 hectares, unless designed by a professional engineer.
- The design capacity of the basin should be at about 50 cubic metres per hectare of drainage area. . The capacity of the basin may be roughly estimated as 40% x Height x Surface area, with the height measured from the bottom of the basin to the crest of the spillway.
- The sediment cleanout level should be 1/3 of a metre below the crest of the spillway.
- The length of the flow path that the water travels should be three to five times the width of the pond. This path length can be accomplished with baffles.
- Drainage options for the basin include armoured spillways, stand pipes and infiltration.


Dewatering riser
Trash rack and antivortex
Pond embankment
Riser
Crest of emergency spillway
Velocity toward outlet
Outlet protection
Inflow
Sediment particles settle due to gravity
Concrete base
Cutoff trench
Barrel
Antiseep collar

Source: Center for Sustainable Design, Mississippi State University, 1999

Installation

- Only general retention basin design and construction practice instructions will be offered here.
- **Site Preparation**

  Clear, grub and remove the topsoil from the area. Compact the area if it has been built up with fill.
- **Embankment**

  Construct the embankment with clean mineral soil: free of roots, woody vegetation, oversized stones, rocks or other objectionable material. Areas on which mineral soil is to be placed should be previously scarified. The mineral soil should contain sufficient moisture to be formed into a ball by hand without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. Place the mineral soil in 1.5-2.0 metres continuous layers over the entire length of the embankment. Compaction can be achieved by driving haul equipment over the mineral soil, so that the entire surface of the fill is traversed by at least one wheel or tread of the equipment. The embankment should be constructed to an elevation 10 percent higher than the design height to allow for settlement.
- **Stand Pipe**

  The riser of the standpipe can be perforated plastic pipes, T-intersections or screened.
- **Spillway**

  The spillway should not be routed over unprotected mineral soil. Design elevations, widths, entrance and exit channel slopes and armouring are critical to the successful operation of a spillway.
- **Vegetative Stabilization**

  The embankment and spillway of the retention basin should be stabilized with temporary vegetation within 15 days of completion of the basin.
- **Erosion and Sediment Control**

  The construction of the retention basin should be carried out in a manner that minimizes erosion and siltation of stormwater.

Maintenance

- Clean out the retention basin before it becomes more than 1/3 full of sediment.

Additional Considerations

- Due to the plastic nature of retention basin sludge, the area of the pond may have restricted land uses after aggregate operations have ceased. If any construction is planned for the area, complete removal of all sludge may be necessary. Alternative uses could be parks, designated gardens or local green spaces.

Sources

Austin, L. (2001): **Construction Stormwater Pollution Prevention.** Stormwater Management Manual ;for Western Washington, Volume II. *Washington State Department of Ecology*, Publication 9912, URL <http://www.ecy.wa.gov/biblio/9912.html>, June 2001.

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United States Department of Agriculture and Mississippi State University. (1999): **Storm Water Retention Pond;** *in* Water Related BMP's in the Landscape/Best Management Practices/Water Runoff Control/D. Water Volume Management. *Watershed Science Institute United States Department of Agriculture and Mississippi State University*, <http://abe.msstate.edu/csd/NRCS-BMPs/contents.html>, October 2001.

United States Department of Agriculture, (1994): **Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater, Best Management Practice Standards.**

United States Department of Agriculture. (2000): **Ponds--Planning, Design, and Construction;** Agriculture Handbook Number 590.

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MAP CODE
MNTC

SCHEDULED MAINTENANCE & REPAIRS

USE

Noise
Risk Management
Stormwater
Pollution Prevention

What

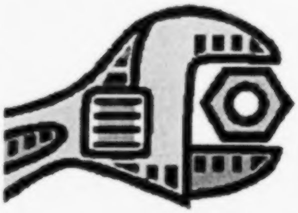
- A regular program of maintenance for vehicles and equipment on site.
- Hydraulic, transmission and engine oil and coolant leaks from vehicles and equipment are some of the most common spills at aggregate operations. A burst hydraulic hose on a large piece of mining equipment can pump tens of litres of hydraulic fluid into the environment in the few seconds before the operator can react and stop the equipment.

Purpose

- Reduce the number of equipment breakdowns, amount of down time and frequency of spills or fuel leaks.
- Improve safety and protect water quality.

Where

YES: Applies to all equipment, vehicles, storage areas, buildings and safety equipment.



Materials, Equipment & Costs

🔧 Lubricants, operating fluids, paints, building materials.
⚒ Mechanic or labourer.
$ Low.

Plans & Specs

- Schedule vehicle maintenance to reduce oil, fuel and coolant leaks.
- Vehicles and machinery require regular maintenance to ensure operator safety.
- Ensure that mufflers, shock absorbers and other noise reducing features are kept in excellent operating condition. This action will help reduce the potential for employee hearing loss, as well as minimize off-site noise impacts and protect surface and ground water quality.

Maintenance

- Preventative maintenance can reduce the quantity and frequency of spills.
- Plan to fix equipment before it breaks by regularly replacing worn hoses and other consumable parts.
- Develop an individual maintenance program for each vehicle and piece of equipment according to amount of use and potential spill hazard.

Sources

Johnson, K. Editor (1999d): **Spill Plan;** *in* Sand & Gravel General Permit. *Washington State Department of Ecology*, Water Quality Program, URL <http://www.ecy.wa.gov/programs/wq/sand/spillpln.html>. June 2001.

MAP CODE
SETL

SETTLING POND

USE
Environment
Pollution
Prevention
Siltation
Processing
Stormwater

What

- A settling pond is an integral part of any processing plant that washes aggregate. Settling ponds can be permanent or semi-permanent structures, dugouts, impoundments or raised tanks.

Purpose

- Settling ponds remove silt and suspended clays from water used for washing aggregate, and/or from dirty stormwater.

Source: USDA Forest Service, 2001

Where

YES: Whenever water is used to wash aggregate, or when stormwater has picked up sediment or requires treatment prior to release to the environment.

NO: Where the risk associated with a failure would pose significant risks for people or natural environments such as streams.

Materials, Equipment & Costs

- Earth, riprap, pipe, collars, seed for stabilization of disturbed soil, new or recycled metal tanks.
- ⚒. Excavator, labourer.
- $ Variable depending upon size and design.

Plans & Specs

- Settling ponds can be made with a number of designs:
  3. Simple dugout
  4. Lined dugout
  5. Bermed pond
  6. Lined bermed pond
  7. Metal tank (new or recycyed).
- Contact the local Mines Branch Regional office for specific Health, Safety & Reclamation Code requirements for larger bermed settling ponds. Larger settling ponds may also require confirmation by a professional engineer.
- A common approach is to construct two or more ponds in series, with the coarsest material removed by the first pond, and the finer suspended solids by subsequent ponds.This approach also allows one or more ponds to operate while another is being cleaned.
- There are a number of ways to calculate the optimum size for a settling pond, with the more technical being beyond the level of detail of this handbook. For sizing advice, an operator is advised to contact either the Regional Mines Branch office or the local office of the Ministry of Sustainable Resource Management.
- Settling ponds should be designed for easy access for clean out with an excavator.
- Locate the settling pond close to the wash plant or, if it is used only for stormwater, close to where the collected stormwater will originate, such as the pit floor. The best locations are generally in low areas and natural drainageways, but NOT in streams or wetlands.
- The distance the water travels within the settling pond should be three to five times the width of the pond. This travel distance can be accomplished with baffles.
- Settling ponds only remove up to roughly 80 percent of the trapped sediment that flows into them. This removal rate should be adequate for recycling back into washing operations.
- For settling ponds used for stormwater only, check that the 80% removal is sufficient to meet allowable discharge turbidity limits. Water with high turbidity levels can be diverted to a land application through a level spreader or gravity fed application pipe (horizontal perfortated PVC).

Installation

- As there are a wide variety of settling pond design types and construction practices, detailed instructions for pond installation are beyond the scope of this manual.
- Site Preparation - clear, grub and strip the topsoil from the area. Compact the area if it has been built up with fill.

Maintenance

- Clean out the settling pond frequently and maintain a capacity of at least 110% of the volume of wash plant water.
- The pond should not be more than 2/3 full during normal operations.

Additional Considerations

- Due to the plastic nature of settling pond sludge, the area of the pond may have restricted land uses after aggregate operations have ceased. If any construction is planned for the area, complete removal of all sludge may be necessary. Alternative uses could include parks, designated gardens or local green spaces.

Sources

Foroozan, L. (2001): **Hydrologic Analysis and Flow Control Design/BMPs;** Stormwater Management Manual for Western Washington, Volume III. *Washington State Department of Ecology*, page 93, Publication 9913, URL <http://www.ecy.wa.gov/biblio/9913.html >. November 2001.

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British Columbia Ministry of Environment, Lands and Parks. (1997): **Guidelines for Assessing the Design, Size and Operation of Sediment Ponds Used in Mining;** *Pollution Prevention Branch.*

MAP CODE
SIGN

SIGNAGE

USE Public Relations
Risk Management

What

- Information and warning signs for the public and site visitors.

Purpose

- To ensure that visitors to the site are aware that the site may be dangerous and that approval is required for entry.
- To deter unauthorized persons from entry and reduce risk of injury.

ACTIVE MINING AREA

DO NOT ENTER

**Other than an Inspector, only persons
authorized by the Manager shall enter
or be permitted to enter a mine.**

HSRC, Part 1.3.1

Mine Name

Contact Phone Number

Source: Ministry of Energy & Mines

Where

YES: In visually prominent locations at the entrance and exit to the operation, as well as at points around the perimeter of the site, particularly fence corners. Post signs at least every 15 to 30 metres and ensure that at least one sign is visible from any point along the fence line.

Materials, Equipment & Costs

- Plywood, metal sheeting, plastic signage products, stencils, paint, wire, nails or staples.
- ⚒ Fasteners for attaching signs to posts, fencing or buildings.
- $ Low.

Plans & Specs

- All signs should be large enough to attract immediate attention, e.g., the "Active Mining Area" sign (shown above) should be at least 600 millimetres x 400 millimetres.
- Keep signs clean and in good repair to maintain maximum visual impact.
- Studies have determined that yellow attracts more attention than red; yellow background with black lettering is an effective combination.

CAUTION

OPEN EXCAVATION
NO TRESPASSING

- Where the pit property fence corners are obstructed by vegetation, the signs should be posted inside the cleared area or at the corners of the pit itself.
- Additional signs should be placed at intervals of no less than 15 metres and no more than 30 metres along the land or pit boundaries.
- Where stockpiles of material are expected to remain for an extended period, and are high enough to present a potential hazard, ramps should be barricaded to prevent vehicle access, and signs posted around the perimeter of the stockpile base to advise the public of potential safety hazards.

CAUTION

UNSTABLE MATERIAL
KEEP OFF

Maintenance

- Signs should be securely mounted and erected in such a way that they will not be easily damaged or stolen.
- Periodically check all signs on the site to ensure they are clean, properly positioned and have not been damaged.

Sources

Mah, K.L. (1987): **Security and Safety of Aggregate Pits;** *Alberta Transportation*, Aggregate Services, Materials Engineering Branch, Aggregates Bulletin #6.

MAP CODE
SILT

SILT FENCE

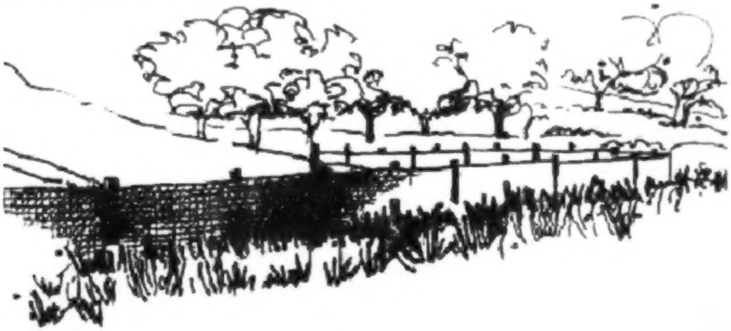
USE
Erosion
Environment
Sediment
Pollution

What

☞ A temporary linear filter barrier of burlap or synthetic filter fabric and posts. Wire fencing is sometimes used as support.

Purpose

☞ Used below disturbed areas to remove or reduce sediment in stormwater run off and sheet or rill erosion.



Silt Fence
Perspective View

Where

YES: Perpendicular to the slope, below disturbed areas where runoff may occur in the form of sheet and rill erosion.

NO: Live streams or swales or ditch lines where flows are likely to exceed 1.0 cubic foot per second (0.3 metres per second).

Materials, Equipment & Costs

☞ Burlap, synthetic filter fabric or geotextile; wire mesh for reinforcement (if necessary); wooden or steel fence posts and staples; wire and ground staples.

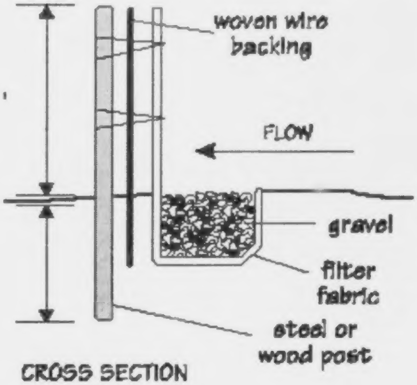
⚒ Labour.

$ Low.

Plans & Specs

- Use only where the size of the drainage area is no more than 0.10 hectares per 30 meters of silt fence length, the maximum slope length above the barrier is 30 meters, and the maximum gradient above the barrier is 50 percent.
- The height of a silt fence should not exceed 0.9 meters. Higher fences may impound volumes of water sufficient to cause failure of the structure.
- To avoid the use of joints, the filter fabric should be purchased in a continuous roll and cut to the length of the barrier.

- Excavate a trench approximately 100 millimeters wide and 100 millimeters deep along the line of stakes and upslope of the barrier. If posts are used rather than stakes, the trench should be 200 millimeters deep.
- When standard strength filter fabric is used, apply a wire fencing to support the fabric. Fasten the fence securely to the upslope side of the posts using heavy-duty wire staples, tie wires or hog rings. Attach the filter fabric to the fencing material with tie wires, plastic zip straps or hog rings.
- When extra strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In such cases the filter fabric is stapled or wired directly to the posts.
- The trench is then backfilled and soil compacted over the filter fabric.



CROSS SECTION
Source: WSDNR, ODGMI

- If a silt fence is to be constructed across a ditch line or swale, the barrier should be of sufficient length to eliminate end flow, and the plan configuration should resemble an arc or horseshoe with the open ends oriented upslope.

Maintenance

- Regular inspections should be conducted after each rainfall and storm to ensure the fence is intact and debris and sediment has not accumulated at the bottom. Remove any deposits when they reach one-half the fence height.
- Silt fences and filter barriers may be removed when they have served their purpose, but not before the upslope area has been permanently stabilized.

Sources

Austin, L. (2001): **Construction Stormwater Pollution Prevention;** Stormwater Management Manual for Western Washington, Volume II. *Washington State Department of Ecology*, page 140 Publication 9912, URL <http://www.ecy.wa.gov/biblio/9912.html>, June 2001.

Norman, D.K., Wampler, P.J., Throop, A.H., Schnitzer, E.F. and Roloff, J.M. (1997): **Best Management Practices for Reclaiming Surface Mines in Washington and Oregon**; *Washington State Department of Natural Resources* Open File Report 96-2 and *Oregon Department of Geology and Mineral Industries* Open File Report O-96-2, page 2-15, URL <http://www.wa.gov/dnr/htdocs/ger/pdf/bmp.pdf>, June 2001.

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United States Department of Agriculture, (1994): **Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater, Best Management Practice Standards.**

MAP CODE
SINK

SINKING THE PLANT

USE Dust
Noise

What

☛ Locating noise generating stationary equipment, such as the processing plant, at a low location on the property; for example, the bottom of the worked pit.

Purpose

☛ To contain noise and dust.

Where

YES: In urban and rural areas where noise may be a concern.

Materials, Equipment & Costs

⚒ Berm building material.
⚒ Excavator, front-end loader.
$ Nil.

Plans & Specs

- Place noise-generating equipment, such as the crusher, in an excavated area below the surrounding terrain.
- Ensure that there is sufficient working space around the equipment so that other machinery can safely access the equipment for normal operations.
- Ensure that there is no danger of sloughing material entrapping personnel or equipment.
- Noise can "leak out" through openings; therefore ensure that there are no gaps in the noise barrier in the directions that noise reduction is most desired.
- Berms and acoustic fences, such as those constructed from used conveyor belts, can be used effectively in combination with a cliff, pit face or pit wall.

Maintenance

- Inspect the area for:
  1. Sufficient space for safety and working area
  2. Sloughing
  3. Noise reduction
- To create an effective barrier, the noise-dampening barrier will likely have to be adjusted on a regular basis.

Sources

Cole, L., Smith, P., Wright, J. and Clough, R. (1999): **Controlling the Environmental Effects of Recycled and Secondary Production Good Practice Guidance;** *United Kingdom Department of the Environment, Transportation and the Regions*, URL <http://www.planning.detr.gov.uk/recycled/practice/index.htm>, June 2001.

MAP CODE
SDRN

SLOPE DRAIN

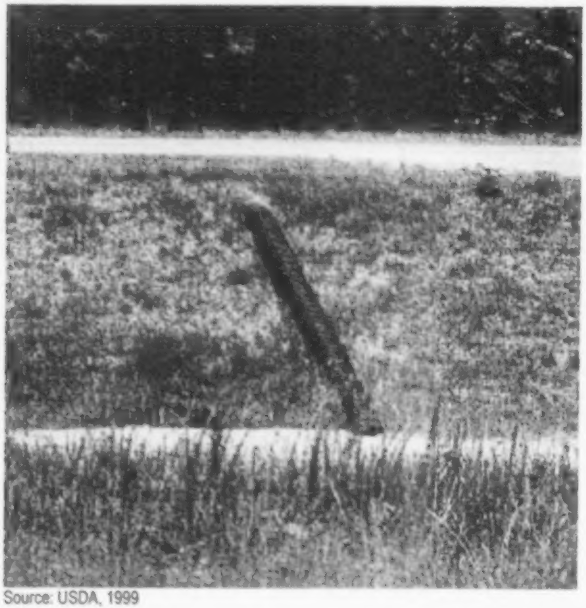
USE Erosion
Sediment
Stormwater

What

- A flexible tube or conduit extending from the top of a cut or fill slope to the bottom.

Purpose

- To temporarily conduct concentrated stormwater runoff safely down the face of a cut or fill slope without causing erosion on or below the slope. Temporary slope drains provide valuable protection of exposed slopes until permanent draining structures and erosion control vegetation can be installed.



Source: USDA, 1999

Where

YES: On cut or fill slopes before permanent stormwater drainage structures are installed and before permanent erosion control vegetation is established.

Materials, Equipment & Costs

- Heavy-duty flexible conduit designed for this purpose, hold down grommets, stakes, riprap for outlet protection.

⚒ Backhoe, labour.
$ Low.

Plans & Specs

- The recommended maximum drainage area per drain is 2 hectares.
- The slope drain should consist of heavy-duty flexible conduit designed specifically for this purpose.
- The diameter of the slope drain should be equal over its entire length.
- Reinforced hold-down grommets should be spaced at 3 metre intervals.
- The entrance to the slope drain should consist of a flared end-section or a standard t-section fitting. Watertight fittings should be used.

Installation

- The entrance section should slope toward the slope drain at a minimum rate of 2 centimeter per metre.
- The soil around and under the entrance section should be hand-tamped in 10 centimeter lifts to the top of the dike to prevent piping failure around the inlet.
- The slope drain should be securely staked to the slope at the grommets provided.
- The slope drain sections should be securely fastened together and have watertight fittings.

Maintenance

- The slope drain structure should be inspected weekly and after every storm and repairs made if necessary.
- Avoid placing any material or traffic on the slope drain.

Sources

United States Department of Agriculture, (1994): **Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater, Best Management Practice Standards.**

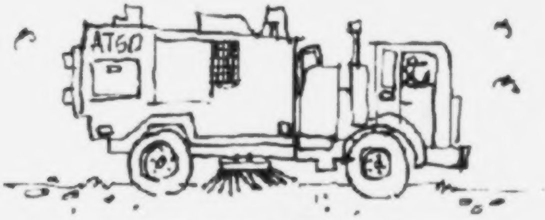
MAP CODE
STCLN

STREET CLEANING

USE
Dust
Traffic
Sediment
Risk Management

What ☛ Sweeping or cleaning the site entrance, the public roadway fronting the site, and on-site paved roads on a regular or as needed basis.

Purpose ☛ To reduce dust and stormwater sediment loading and maintain a clean appearance at the site entrance and adjacent public roads.



Parking Lot and Street Cleaning Sweeper

Where **YES:** Site entrance, public road fronting the site, loading areas, haul roads, parking areas and truck aprons.

Materials, Equipment & Costs

☛ Flusher truck, power street sweeper using dry or wet broom action and/or vacuum pickup.

⚒ None.

$ Low.

Plans & Specs

- New street sweeping machines pick up much finer materials than older models, and therefore collect more dust particles and sediment-bound pollutants.
- Sweepers with high-powered vacuum systems can be effective in collecting surface sediment and dirt, while reducing the amount of dust released.

Options

- In some areas of the Province, street-cleaning companies can be contracted to keep the site entrance clean on a regular basis.

Maintenance

- Schedule a regular street cleaning program, as well as monitoring "as needed" requirements.

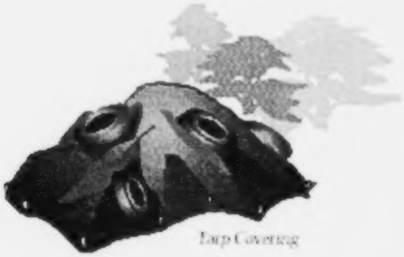
MAP CODE
TARP

TARPS

USE
Dust
Erosion
Stormwater

What ☛ A piece of woven fabric or plastic sheeting material (tarpaulin) used to temporarily cover soil, raw materials, equipment or activities to provide protection from wind and rain.

Purpose ☛ To prevent or reduce erosion, sloughing, dust and muddied stormwater runoff.



Tarp Covering

Where **YES:** Stockpiled raw material, specialty items, benches and exposed topsoil, overburden, idle equipment.

Materials, Equipment & Costs

- Tarpaulins made of synthetic fabric of vinyl, vinyl-coated polyester or polyethylene; canvas; pins or stakes; ropes or ties; weights (could be bricks, tires, sandbags, etc.).
- ⚒ Labour to cover subject area or object and secure tarp.
- $ Low.

Plans and Specs

- Black, green or brown tarps will reduce negative visual impact, as opposed to more vivid orange or blue colours commonly available.
- Tarps should be put in place as quickly as possible to minimize erosion and dust.
- Tarps need to be secured using stakes, tie downs, tires, etc., to avoid being blown away by the wind.
- When using several tarps to cover an area, place the lowest tarp first and lay subsequent tarps in an overlapping shingle fashion to ensure water is unable to seep through at the edges.
- Tarps are a short term, temporary solution. If long-term protection is required, consider using vegetation and silt fences to control stormwater erosion and dust.

Maintenance

- Deterioration will occur due to sunlight and wind. Regular inspections should be conducted to ensure that no holes or gaps are present.
- Tarps should be repaired or replaced if they become damaged.

Sources

King County Washington (1999): **Stormwater Pollution Control Manual;** Department of Natural Resource, Water and Land Division, URL <http://dnr.metrokc.gov/wlr/dss/spcm.htm>, October 2001.

MAP CODE
TARP

TILLAGE

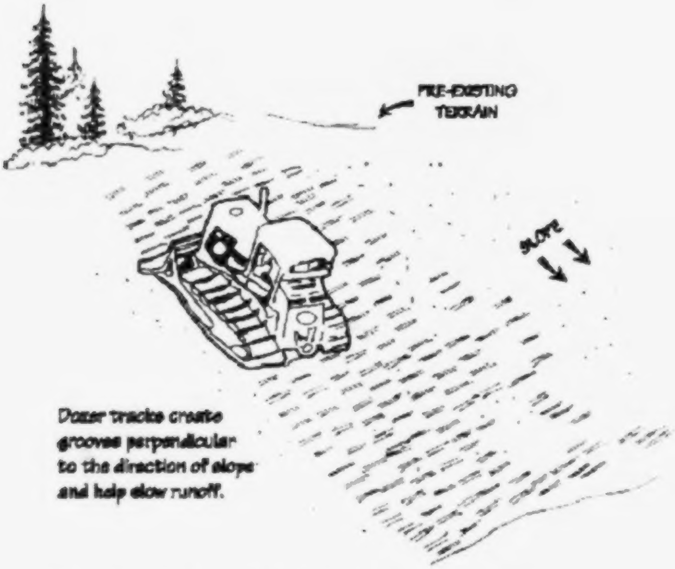
USE
Erosion
Reclamation
Sediment Control
Water Quality

What

- Roughening of exposed soil surface with horizontal grooves running across the slope.
- Achieved by tractor with disc attachment or by stair stepping or tracking with construction equipment.
- Often done during reclamation.

Purpose

- To shape the surface of the soil and create pockets that prevent runoff, minimize pondage, and catch and retain moisture.
- Can also break up restrictive layers below normal plough depth that inhibit water movement or root development.
- Aids the establishment of vegetative cover, improves water infiltration and decreases runoff velocity.


PRE-EXISTING TERRAIN
SLOPE
Dozer tracks create grooves perpendicular to the direction of slope and help slow runoff.

Source: Center for Sustainable Design, Mississippi State University, 1999

Where

YES: During reclamation, especially in poorly drained or compacted areas. Also, any flat to nearly flat land having poor drainage, such as recently reclaimed areas or cleared or grubbed areas not yet put into extraction.

Materials, Equipment & Costs

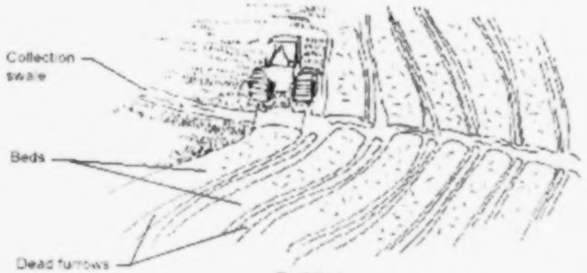
None.

⚒ Bulldozer, tractor, harrow or chisel blades.

$ Minimal.

Plans & Specs

- A neat or uniform appearance is not important: the rougher the soil, the better.
- Grooves can be large-scale, such as stair-step grading with small benches or terraces, or small-scale, such as grooving with disks, tillers or other machinery.
- Heavy tracked machinery should be used only if soil is sandy and non-compressible.
- Restrictive soil layers should be less than 40 centimetres deep.
- Bedding is a technique of creating narrow width ploughed tracks with equally spaced dead furrows running perpendicular to the prevailing land slope. This configuration is accomplished by moving soil toward the centre of beds to form a series of ridges and dead furrows (troughs) that will minimize runoff and pondage.



Bedding
Perspective View

Source: NRCS, 1999

Maintenance

- Minimal.
- Inspect roughened areas after heavy rainfalls to ensure erosion has not occurred.

Sources

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MAP CODE
SOIL

TOPSOIL MANAGEMENT

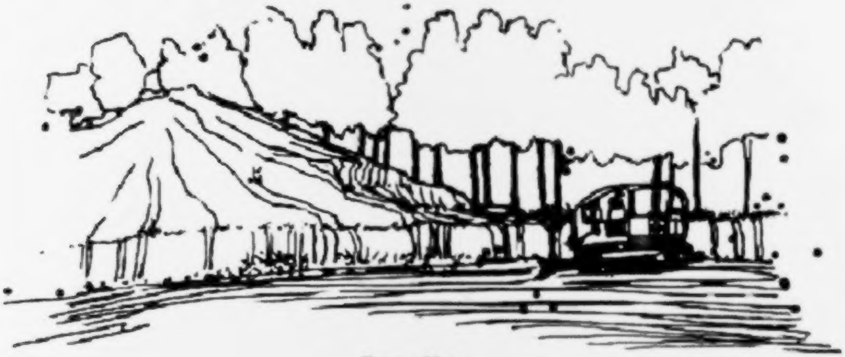
USE
Dust
Erosion
Sediment
Visual

What

- Salvaging, storing and using topsoil for rehabilitation.

Purpose

- To retain site topsoil for rehabilitaiton and/or permit requirements.
- To preserve topsoil quality during moving and storage.



Topsoiling
Perspective View

Source: US Department of Agriculture

Where

YES: All areas with well-developed topsoil (i.e., thickness greater than 7 centimeters).

Materials, Equipment & Costs

None required.
⚒ Earth moving equipment.
$ Low.

Plans & Specs

Materials

- Determine depth of topsoil on 10-metre spacing.
- The depth of material should be at least 7 centimetres. Soil factors such as rock fragments, slope, depth to water table and layer thickness affect the ease of excavation and spreading of topsoil.
- Keep topsoil separate from overburden, and store layers separately to ensure that material is restored in the same order that it was removed.
- Generally, the upper part of the soil that is richest in organic matter is most valuable.
- Organic soils such as muck and peat do not make good topsoil. They can be identified by their extremely light weight when dry.

Stripping

- Strip topsoil only from those areas that will be disturbed by excavation, filling, road building or compaction by equipment. A 1.0 to 1.5 metre stripping depth is common, but depth will depend on the soil profile at the site. Determine depth of stripping by taking soil cores at several locations within each area to be stripped. Topsoil depth generally varies along a gradient from hilltop to toe of slope. Put sediment basins, diversions and other controls into place to manage stormwater before stripping.

Stockpiling

- Select stockpile location to avoid slopes, natural drainage ways and traffic routes. At large sites, re-spreading is easier and more economical when topsoil is stockpiled in small piles near the areas where they will be used.
- Sediment barriers - use sediment fences or other barriers where necessary to retain sediment.
- Temporary seeding - protect topsoil stockpiles by temporarily seeding as soon as possible, within 30 days after the formation of the stockpile.
- Permanent vegetation - if stockpiles will not be used within 12 months they should be stabilized with permanent vegetation to control erosion and weeds.

Installation

Site Preparation

- Before spreading topsoil, establish erosion and sedimentation control structures such as diversions, berms, dikes, waterways and sediment basins.
- Maintain grades on the areas to be topsoiled according to the approved plan. Adjust grades and elevations for receipt of topsoil.
- Roughening - Immediately prior to spreading the topsoil, loosen the subgrade by disking or scarifying to a depth of at least 100 millimetres to ensure bonding of the topsoil and subsoil.
- Ensure that soil horizons are replaced in the same order that they were removed.
- Uniformly distribute topsoil to pre-mining thickness. If sufficient topsoil is available, a minimum compacted depth of a half metre on 3:1 slopes and one metre on flatter slopes is suggested. To determine the volume of topsoil required to various depths, use the table below. Do not spread topsoil while it is frozen or muddy.

Volumes of topsoil required for various depths

Depth (millimetres)	Cubic metres per 100 square metres	Cubic metres per hectare
25	2.5	250
50	5.0	500
75	7.5	750
100	10.0	1000
125	12.5	1250
150	15.0	1500

- Compact the topsoil enough to ensure good contact with the underlying soil, but avoid excessive compaction, as it increases runoff and inhibits seed germination. Light packing with a roller is recommended where turf is to be established.
- On slopes and areas that will not be mowed, the surface may be left rough after spreading topsoil.

Options

Live Topsoiling

- Live topsoiling is extracting topsoil from its place of origin and placing it directly onto an area that has already been mined, backfilled and graded for reclamation.
- This is the most desirable topsoil management option, as the topsoil is handled only once and does not compact during storage within stockpiles.

Maintenance

- Minimize erosion with timely planting of temporary or permanent vegetation.
- Ensure that temporary or permanent plantings are well watered until established.
- Inspect stockpiles regularly, especially after large storms. Stabilize any areas that have eroded.

Sources

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MAP CODE
VEGC

VEGETATION COVER

[illegible]

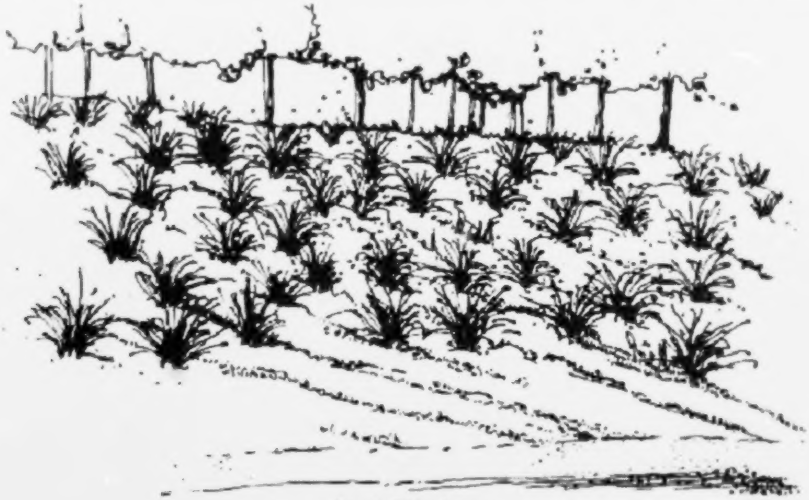
USE
Dust
Erosion
Noise
Stormwater
Visual

What

- Ground cover (grasses & legumes), trees, shrubs or perennial plants.
- Sometimes consists of planting naturally occurring species to enhance existing cover.
- Vertical density of large shrubs and trees creates a vegetative "screen".

Purpose

- To minimize or control dust and erosion, enhance water quality or facilitate reclamation.
- When densely planted, can control the growth of noxious weeds.



Bank Planting
Perspective View

Source: Mississippi State University

Where

YES: At any location where plant life will control dust creation (a dense vegetative cover), dust transportation (vegetative screen), erosion (fiberous root system), water quality (filtering, oxygenating aquatic plants), help to preserve topsoil and overburden or facilitate reclamation (re-establishment of native plant life).

Materials, Equipment & Costs

- Plants seeds and fertilizer appropriat to the situation
- Backhoe, shovel, broadcast seeders, piping or hoses, labour and sprinklers.
- $ Low.

Plans & Specs

- Dependent on individual situation (see table below):

Planning suggestions for vegetation cover

Situation	Planning Suggestions
Dust control	dense vegetative screen of trees and shrubs, ground cover
Erosion control	fast growing grass or groundcover with a fiberous root system
Water treatment	marginal plants, filtering and oxygenating aquatic plants

- Vegetative cover should also be considered for stockpiles of topsoil and overburden to seal and control dust and limit erosion.
- Native plantings are the best to use for reclamation as they generally require less maintenance. Avoid introducing a foreign species into an ecosystem.
- A bioengineering specialist may be consulted for use of vegetation to control erosion, and to tailor a seed mix specifically optimized for the site.
- Ongoing irrigation may be required for well-drained or south-facing sites.

Maintenance

- Ensure newly planted material receives sufficient water and fertilizer until established.
- All newly planted vegetation should be checked regularly, and difficult sites may require special attention such as more or less water, wind protection, etc.

Sources:

United States Department of Agriculture and Mississippi State University. (1999): **Native Revegetation - Grasses, Legumes, and Forbs** and **Native Revegetation - Trees and Shrubs;** *in* Water Related BMP's in the Landscape/Best Management Practices/Water Runoff Control/ C. Erosion Control, and Temporary Seeding, in .../ A. Construction Site Impact Reduction, *Watershed Science Institute United States Department of Agriculture and Mississippi State University*, <http://abe.msstate.edu/csd/NRCS-BMPs/contents.html>, October 2001.

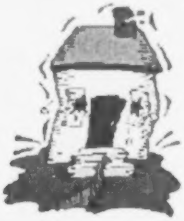
MAP CODE
VIBR

VIBRATION REDUCTION

USE
Dust
Air Quality
Noise

What ☛ The reduction of minor ground movements generated by production blasts, crushers and haul trucks driving over rough ground.

Purpose ☛ To reduce minor ground vibrations that may annoy neighbours and negatively affect the community's acceptance of the operation.



Where **YES:** Blasting, drilling, screening, crushering, grading processed material, transporting of processed material.

Plans & Specs

- The main cause of vibration during transport is uneven road surfaces. The level of vibration depends upon the vehicle speed and weight, type of soil and the size of road surface irregularities.
- Consult with a drilling and blasting specialist regarding blast pattern and procedures.
- Remove significant road surface irregularities.
- Reduce speeds.
- Re-route dump trucks to less sensitive roads.
- introduce a weight limit on sensitive roads.
- Monitor vibrations at the nearest receptor during blasting. Considerations include the charge weight per delay, length of delay, blast hole spacing and firing sequence.

Maintenance

- Monitor for potholes.

Sources Cole, L., Smith, P., Wright, J. and Clough, R. (1999): **Controlling the Environmental Effects of Recycled and Secondary Production Good Practice Guidance;** *United Kingdom Department of the Environment, Transportation and the Regions*, URL <http://www.planning.detr.gov.uk/recycled/practice/index.htm>, June 2001.

MAP CODE
WATER

WATER SPRAY

USE Dust

What

- The use of water sprays, sprinklers, mists or foams wherever dust is created at the aggregate site.

Purpose

- To control dust generation and dispersal with water. Foams and wetting agents can enhance the effectiveness of water in binding dust particles.

Photo: Sedun (RMX Recycling Ltd., Victoria)

Where

YES: Feeds and discharges for crushers, screens, transfer point for conveyors, stockpiles, and non-covered trucks ready for departure.

Materials, Equipment & Costs

Agricultural sprinklers or foggers, irrigation pipe, automated dust control water spray or bar system.

⚒ Hand tools necessary for installation.

$ Dependant upon system.

Plans & Specs

- Use elevated agricultural sprinklers for stockpile areas.
- Use sprinklers, sprayers and foggers for local dust control.
- Water systems require careful design with consideration of automation, supply requirements, spray head configuration, prevention of freezing and clogging due to dust.
- With water sprays and mists, a surface wetting is all that is required. Too much water will necessitate drying of material and cause machine wear and tear.

- Most water suppression should use fine mists rather than large quantities of water, with the exception of elevated sprinkler systems.
- Positioning the spray heads close to the dust source will allow for use of mist, as smaller water droplets cannot travel as far as larger ones.

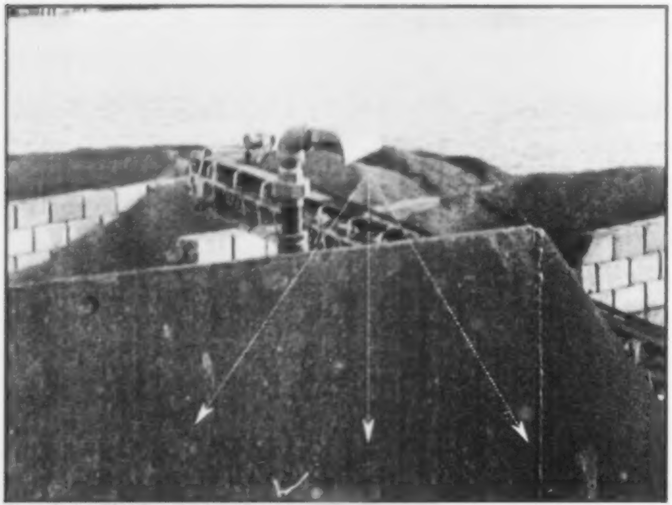


Photo: Sedun (RMX Recycling Ltd., Victoria)

Maintenance

- Regular inspections are required to ensure that mineral deposits do not build up inside the nozzles.
- Take precautions to avoid damage to the system during freezing temperatures.

Sources:

Aggregates Manager (2000): **Contemporary Solutions to Dust Control Problems,** Operation Strategies.

MAP CODE
WWASH

WHEEL WASHER

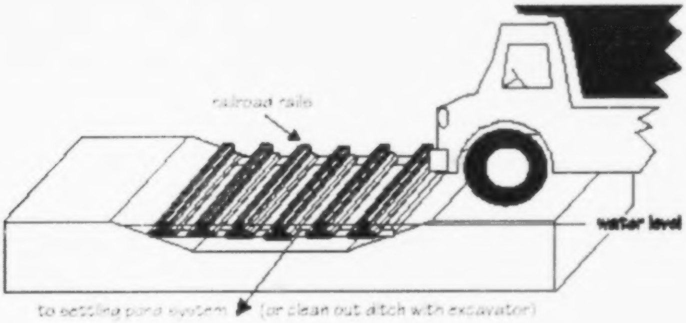
USE
Dust
Public Relations
Sediment

What

- A washing pit or trough that removes rocks and dirt from vehicle wheels and wheel wells as they drive through.

Purpose

- To reduce the amount of dirt and rock carried by aggregate vehicles onto public roads, thus lessening the need for street sweeping and preventing windshield damage.
- To create a cleaner, less dusty site by collecting the material in one place.



Where

YES: Between the scale and the property exit.

Materials, Equipment & Costs

- Railroad rails, steel bars or grid, gravel, water.
- ⚒ Back hoe and labourer.
- $ Medium to high.

Plans & Specs

- Wheel washers can range from simple troughs to concrete foundations with embedded rails.
- The basic wheel washer is a shallow pit filled with water.
- A rumble strip on the bottom of the pit, such as a cattle guard, railroad rails or steel bars spaced 5 to 20 centimeters apart, can agitate/shake mud and dirt off the vehicle.
- High volume wheel washers may need a concrete foundation.
- Mechanized spray washers are also available through commercial suppliers.

- Allow at least 20 metres between the wheel washer and the exit for wetted material to spin off tires as the vehicle comes up to speed, and for other material to drop off the chasis.
- A paved exit will also help reduce the amount of dirt and rocks deposited on public roads by vehicles leaving the site.
- Dry options use only mechanical agitation to remove dirt and mud.
- On more remote sites, 30 metres of loose clean gravel will remove a good portion of mud from the tires.
- Cattle guards by themselves will also remove a significant amount of mud and dirt.

Maintenance

- Dirty water can be directed to a settling pond, or the wheel wash can be cleaned out frequently with an excavator. Make sure that the water used in the wheel washer is treated to remove solids and turbidity before being discharged off the site.

Sources

Norman, D.K., Wampler, P.J., Throop, A.H., Schnitzer, E.F. and Roloff, J.M. (1997): **Best Management Practices for Reclaiming Surface Mines in Washington and Oregon**; *Washington State Department of Natural Resources* Open File Report 96-2 and *Oregon Department of Geology and Mineral Industries* Open File Report O-96-2, 128 pages, URL <http://www.wa.gov/dnr/htdocs/ger/pdf/bmp.pdf>, June 2001.

MAP CODE
WIND

WIND PROTECTION

USE
Dust
Erosion
Sediment

What

- Any structure or method to block or reduce wind flow.

Purpose

- To reduce the exposure of dust-generating material to wind, or reduce the velocity of wind, thus controlling dust generation and distribution and maintaining air quality.

Where

YES: Primarily around processing equipment such as screens, crushers, conveyors, hoppers and chutes, but also around stockpiles and roads.

Materials, Equipment & Costs

Trees, plywood, lumber, tarps, metal sheeting, used tires (to make a wall or barrier).
Labour.
$ Low.

Plans & Specs

- For the property as a whole, wind protection includes constructing treed berms and retaining as many original trees and shrubs as possible.
- For individual equipment or activity, wind protection includes placing barriers directly in front of dust generating activities to create small, localized wind shadows.
- The creation of small wind shadows will allow locally generated dust to fall out before it can be caught by the wind and carried off-site.
- Awareness of the wind direction and strength at the site will help in the placing of both large and localized wind barriers.

Options

- Backstops
  Backstops are freestanding walls of plywood, fencing, used tires or used conveyor belts placed between the prevailing wind and any dust generating point sources.

- Diverters
  Diverters are smaller barriers attached to equipment or located right next to equipment or point sources of dust. They can be made from plywood or sheet metal.
- Vegetative Cover
  A dense vegetative screen consisting of trees and shrubs can reduce the impact of wind and resultant spread of dust on a specific location. Trees and shrubs require time to grow and are not mobile (see Vegetation Cover BMP).
- Containment / Enclosure
  Any type of enclosure for conveyors, chutes, process plant, stockpiles, etc. Enclosures can include hoods, dust socks, blasting mats and buildings in which plants such as crushers or screens can operate.
- Temporary Enclosures
  Can be constructed using sheet material such as plywood on scaffolding or masonry materials. Straw bail walls supported with scaffolding have also been effectively used for both wind and noise barriers.
- Bays or Bunkers
  Storing aggregate in bays or bunkers made with lumber or pre-cast concrete blocks will help shield granular material from the wind.
- Tarping loads
  Spillage and blow-off of fine material from dump trucks can be prevented by tarping the load (see Tarps).

Maintenance

- Minimal, dependent on systems used.

Sources

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